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(2)

ENVIRONMENTAL ASSESSMENT

PROPOSED AIRCRAFT CONVERSION

102nd FIGHTER INTERCEPTOR WING

MASSACHUSETTS AIR NATIONAL GUARD

OTIS AIR NATIONAL GUARD BASE, MASSACHUSETTS
JUNE 1987

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ENVIRONMENTAL ASSESSMENT OF AN AIRCRAFT CONVERSION, 102nd FIGHTER INTERCEPTOR WING, MASSACHUSETTS AIR NATIONAL GUARD, OTIS AIR NATIONAL GUARD BASE, MASSACHUSETTS

AIR NATIONAL GUARD SUPPORT CENTER
Environmental Protection Branch
Andrews Air Force Base, Maryland

June 1987

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LIST OF ABBREVIATIONS AND ACRONYMS

%	percent
$\mu g/m^3$	micrograms per cubic meter
AB	Air Base
ADNL	A-weighted day-night noise level
AFOSH	Air Force Occupational Safety and Health
AGL	above ground level
AICUZ	Air Installation Compatible Use Zone
AMRL	Aerospace Medical Research Laboratory
ANG	Air National Guard
ANGB	Air National Guard Base
AQCR	Air Quality Control Region
ARNG	Army National Guard
Bldg.	building
CDNL	C-weighted day-night noise level
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
CO	carbon monoxide
CSEL	C-weighted sound exposure level
CUD	compatible use district
CZMA	Coastal Zone Management Act of 1972
dB	decibels
deg	degree(s)
DEQE	Department of Environmental Quality and Engineering (Massachusetts)
DLA	Defense Logistics Agency
DOD	Department of Defense
EA	environmental assessment
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FIW	Fighter Interceptor Wing
FY	Fiscal Year
Fig.	figure
ft	feet
gal	gallon(s)
gpd	gallons per day
h	hour(s)
H-70	mixture of 70% hydrazine and 30% water
HC	hydrocarbons
HTH	high-test hypochlorite (65% calcium hypochlorite)
I&R	inspection and repair
km	kilometer(s)
L_{dn}	day-night average sound level
m	meter
mg/L	milligrams per liter
mL/L	milliliters per liter

mi	mile(s)
min	minute(s)
MSL	mean sea level
Mass.	Massachusetts
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NTU	nephelometer turbidity units
O_3	ozone
OEHL	Occupational and Environmental Health Laboratory
oz	ounce(s)
PCU	platinum-cobalt color unit
PMEL	Precision Measurement Equipment Laboratory
ppm	parts per million
s	second
SEL	sound exposure level
SHPO	State Historic Preservation Officer
SO_2	sulfur dioxide
Sec.	section
TSP	total suspended particulates
USAF	U.S. Air Force
VA	Veterans Administration
VR	visual route

ENVIRONMENTAL ASSESSMENT OF AN AIRCRAFT CONVERSION, 102nd FIGHTER INTERCEPTOR WING, MASSACHUSETTS AIR NATIONAL GUARD, OTIS AIR NATIONAL GUARD BASE, MASSACHUSETTS

SUMMARY

It is proposed that the Massachusetts Air National Guard 102nd Fighter Interceptor Wing at Otis Air National Guard Base convert from 15 F-106 aircraft to the preferred option of 18 F-15 aircraft. The only other viable alternative is conversion to F-16 aircraft. The primary impacts of the proposal would be positive. Some facility construction and modification projects and increased land easement requirements would be associated with the conversion. Noise modeling indicates that the conversion from F-106 to either replacement aircraft would reduce noise impacts in the vicinity of the air base. After the proposed F-15 conversion, emissions of carbon monoxide, hydrocarbons, and total suspended particulates would be reduced, while emissions of nitrogen oxides and sulfur dioxide would increase. The increase in nitrogen oxides and sulfur dioxide emissions would lead to very small incremental increases in ambient concentrations, with total concentrations maintaining National Ambient Air Quality Standards. The emissions by aircraft of all air pollutants of concern would remain the same or be reduced if the conversion was to the alternative F-16 aircraft. Although some minor impacts would occur during facility construction and modification activities, it is predicted that no major adverse impacts or cumulative effects would result from the proposed aircraft conversion. This assessment incorporates information contained in the Army master plan for Camp Edwards, Massachusetts Military Reservation.

1 INTRODUCTION

1.1 SCOPE AND PURPOSE OF THE PROPOSED ACTION

The U.S. Air Force (USAF) continues to modernize Air National Guard (ANG) units by replacing existing aircraft with newer models; this is referred to as aircraft conversion. This document provides an environmental assessment of a proposed aircraft conversion for the 102nd Fighter Interceptor Wing (FIW) of the Massachusetts ANG at Otis Air National Guard Base (Otis ANGB) on Cape Cod, Massachusetts.

The strategic air defense mission is considered vital to the national defense and must be continued. This priority has been established at all decision-making levels of the U.S. Department of Defense (DOD). It has been specifically accepted by the National Command Authority through inclusion in annual Presidential budget submissions and has been confirmed by the Congress.

In accordance with the administration's *Total Force Policy*, it is a national defense objective to increase the Reserve Forces' responsibility for maintaining the nation's air combat capability. As part of a general upgrading of ANG combat capability

and modernization of the ANG aircraft inventory, the strategic air defense mission is being enhanced. The 102nd FIW is charged with maintaining combat readiness and sufficient mobility to be deployed in the event of a federal activation. The proposed action addressed in this document is replacement of the 15 F-106 aircraft currently assigned to the 102nd FIW with one of two alternatives, either 18 F-15 or 18 F-16 aircraft. It is expected that three of the newly assigned aircraft would be deployed to Loring AFB, Maine, to support an alert detachment. Since the deployment requirement is subject to change, this EA addresses the worst-case scenario, wherein all 18 aircraft would be stationed at Otis ANGB. Conversion to the F-15 is considered the preferred alternative because that aircraft has greater air-to-air combat capabilities, increased range and loiter time in the intercept area, and pulse-doppler radar for long-range detection and tracking of small, high-speed objects. The specific purpose is to modernize the equipment of the Massachusetts ANG and to upgrade the potential contribution of the 102nd FIW to the national defense posture.

1.2 SUMMARY OF ENVIRONMENTAL-STUDY REQUIREMENTS

Under the National Environmental Policy Act of 1969 (NEPA), federal agencies are required to take into consideration the environmental consequences of proposed actions in the decision-making process. The intent of NEPA is to protect, restore, or enhance the environment through well-informed federal decisions. The Council on Environmental Quality (CEQ) was established under NEPA to implement and oversee federal policy in this process. To this end, CEQ has issued *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* (40 CFR 1500-1508) (CEQ, 1978). The CEQ regulations specify that an environmental assessment be prepared that serves to:

- Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact;

- Aid an agency's compliance with the Act (NEPA) when no environmental impact statement is necessary; and

- Facilitate preparation of a statement when one is necessary.

To comply with NEPA, the planning process for the proposed aircraft conversion will include a study of environmental issues related to the proposed conversion, including those related to construction of new facilities, modifications of existing buildings, and the need for additional land easements. The purpose of this document is to analyze the impacts of the proposed conversion and provide information to determine whether an environmental impact statement should be prepared.

2 THE THREE ALTERNATIVES

2.1 CONVERSION ALTERNATIVES

2.1.1 Introduction

The USAF is proposing to convert from the F-106 to the F-15 or the F-16 aircraft at the 102nd FIW, based at Otis ANGB on Cape Cod, Massachusetts. In February 1985, the Air Force announced the proposed conversion of the 102 FIW from 15 F-106 aircraft to 18 F-16 aircraft, with the continued mission of air defense. The F-16 aircraft were proposed because they were the only modern fighter aircraft available at the time. Since then, a restructuring of the fighter force has made F-15 aircraft available, and conversion to this aircraft is now the preferred alternative. The ANG is planning additional safety easement acquisitions, miscellaneous building alterations, and the construction of one new facility to support the F-15 aircraft conversion. The alternatives to the F-15 conversion are to convert to the F-16 or do nothing.

2.1.2 Characteristics of the F-15 Aircraft

The F-15 is an all-weather, extremely maneuverable tactical fighter aircraft designed and manufactured by McDonnell Douglas Corporation. Powered by two Pratt and Whitney F-100-PW-100 turbofan engines with an afterburner that generates 25,000 lb of thrust from each engine, the F-15 has a combat ceiling of 65,000 ft and a ferry range of 3,450 mi. Maximum takeoff weight is 68,000 lb, and the aircraft normally takes off without reliance on the afterburner.

2.1.3 Characteristics of the F-16 Aircraft

The F-16 is a compact, multirole fighter aircraft designed and manufactured by the General Dynamics Corporation. Powered by one Pratt and Whitney F-100-PW-200 turbofan engine with an afterburner that generates 25,000 lb of thrust, the F-16 has a combat ceiling of greater than 50,000 ft and a ferry range of more than 2,000 mi. Maximum takeoff weight is 35,400 lb, and the F-16 can take off without reliance on the afterburner.

2.1.4 Aircraft Operations

Regardless of the conversion alternative implemented, the 18 replacement aircraft would fly a total of about two more sorties* per day than the existing 15 F-106 aircraft because more aircraft would be available. The replacement aircraft may

*A sortie is an individual flight; it consists of a departure, an approach, and one or more closed patterns.

practice low approaches and touch-and-go landings and would usually take off without using afterburners. Air traffic patterns would be consistent with established local procedures at the Otis ANGB. Normal operations would be conducted Monday, Wednesday, and Friday between 8:30 a.m. and 5:00 p.m. On Tuesday and Thursday, flight operations would be from 8:30 a.m. to 9:30 p.m. During the monthly Unit Training Assembly weekend, flying operations also would be conducted on Saturday and Sunday from 8:00 a.m. to 5:00 p.m. In addition, flight operations would occur on one other Saturday during the month from 8:00 a.m. to 5:00 p.m. The F-106 aircraft currently assigned to the 102nd FIW fly about 220 sorties per month for an average of 1.6 h each sortie. This amounts to more than 4,200 hours of flight time annually. The annual flight time with the change in aircraft would still be under 5,000 h.

Differential accident rates have been experienced among the F-106, F-16, and F-15 aircraft. The rate for the F-106 for the life of the aircraft has been 9.13 accidents per 100,000 flying hours. No F-106 accidents occurred in FY86. The F-15 and the F-16 have experienced accident rates of 3.86 and 7.25 accidents per 100,000 flying hours, respectively, over the life of the aircraft. The reduced probability of accidents with the F-15 and the alternative F-16 over the current F-106, combined with essentially no change in hours flown annually, would result in a net positive benefit regarding accident potential associated with the proposed conversion.

2.1.5 Personnel Summary

Table 2.1 shows that the conversion from F-106 to F-15 at Otis ANGB would result in a 9.3% increase in full-time employment and a 10.2% increase in part-time employment. Conversion to F-16 aircraft would cause a 0.3% increase in full-time employment and an 8% increase in part-time employment.

TABLE 2.1 Staffing Requirements for the Three Alternatives

	Personnel Required			Staff Change		Percent Change	
Category	F-106[a]	F-15[b]	F-16	F-15	F-16	F-15	F-16
Full-time	642	702	644	+60	+2	+9.3%	+0.3%
Part-time	975	1,074	1,057	+99	+82	+10.2%	+8.0%

[a]No-action alternative.

[b]Preferred alternative.

2.1.6 Construction Program

Various construction projects would be required to support conversion to a newer replacement aircraft at the Otis ANGB. The cost of these projects would be $9.16 million for the preferred F-15 alternative and $9.34 million for the F-16 alternative.

F-15 Alternative

The preferred F-15 conversion program would require the construction of a munitions maintenance and storage facility and a composite squadron operations facility. In addition, a number of existing facilities would be altered. These include the avionics/precision measurement equipment laboratory, aircraft arresting system, and engine inspection and repair (I&R) shop. The total construction cost for all of these improvements is estimated at $9.16 million.

F-16 Alternative

In addition to a munitions maintenance and storage facility and a composite squadron operations facility, the F-16 alternative would include an alternate fuel facility. The alteration of existing facilities would be the same as for the preferred alternative. The construction cost for this alternative is estimated to be $9.34 million.

2.2 NO-ACTION ALTERNATIVE

The F-106 was originally designed for an airframe life of 6,000 h flying time. Although the aircraft have been continually serviced and in some cases their wings reskinned, the remaining useful life of the aircraft is limited. The F-106 is essentially 30 years old, and replacement parts for maintenance will soon be unavailable. The no-action alternative would mean that (1) the 15 F-106 aircraft currently assigned to the 102nd FIW at Otis ANGB would remain in place, (2) construction planned specifically for the conversion would not take place, (3) the personnel requirements for the base would remain essentially unchanged, and (4) the limited life of the F-106 aircraft would result in dissolution of the ANG unit.

2.3 ENVIRONMENTAL CONSEQUENCES

2.3.1 Proposed Conversion

Operations involving any hazardous materials resulting from the conversion at Otis ANGB would be carried out in accordance with appropriate state and federal regulations and are not expected to result in significant adverse effects.

Some interference with local traffic could occur on the roads used by construction-related vehicles entering and exiting the base.

Reduced noise during takeoffs by the replacement aircraft would cause environmental enhancements during the mating and nesting period of the state threatened and endangered bird species located at the Otis ANGB. Furthermore, the additional 51-acre restrictive easements associated with the expanded munitions storage .acility and the alert facility would provide habitat for natural vegetation and wildlife.

There would be no additional effect on the groundwater resources in this area of the Cape because the number of aircraft and personnel would not substantially change from present levels.

In addition, no environmental disturbances are anticipated in the following areas: herbicides and pesticides, land and soil quality, vegetation and wildlife resources, socioeconomic factors, coastal zone management issues, and cultural resources.

Conversion to the F-15, the preferred action, would result in a 9.3% increase of full-time staff and a 10.2% increase of part-time staff associated with support activities at the base. Implementation of the F-16 alternative would result in 0.3% and 8% increases in full-time and part-time staff, respectively. Temporary construction workers would be needed for the various construction and alteration projects associated with either conversion alternative.

In terms of air quality, pollutant emissions would remain the same or be significantly reduced with the conversion from F-106 to F-16 aircraft. For conversion to the F-15, emissions of CO, HC, and TSP would be reduced, while emissions of NO_x and, to a lesser extent, SO_2 would increase. Despite the increases in NO_x and SO_2, concentrations of these air pollutants would remain in compliance with National Air Quality Standards. A short-term increase in the fugitive dust emissions would occur during construction activities associated with either conversion alternative.

Noise also would be reduced as a consequence of converting to either the F-16 or F-15 aircraft. Conversion to the F-16 aircraft would result in a maximum reduction of 5-10 decibels, as measured on the L_{dn} (24-h average sould level) scale; the corresponding decrease for conversion to F-15 aircraft would be 10-12 decibels. This reduction would constitute an environmental benefit resulting from the conversion. Evaluation of the combined impacts of Massachusetts Army National Guard (ARNG) impulsive noise and noise from other aircraft indicated that:

- The critical isopleths representing ARNG blast (impulsive) noise impacts and ANG/Coast Guard noise impacts for the F-106 scenario would overlap only inside the Massachusetts Military Reservation. No contour overlap would occur either for the F-16 or F-15 scenarios.

- At sensitive community locations, the additive effect of simultaneous jet, helicopter, and gunfire noise events would be reduced by the conversion to either replacement aircraft.

2.3.2 No-Action Alternative

If the proposed action does not occur, the ANG mission and current operations would remain unchanged. No new perturbations to the environment on Cape Cod would result. Conversely, the changes in air quality and noise conditions projected for the F-15 or F-16 conversion would not occur under the no-action alternative. The limited life of the F-106 aircraft would ultimately result in the dissolution of the ANG unit.

3 AFFECTED ENVIRONMENT

3.1 PHYSICAL AND DEMOGRAPHIC SETTING

3.1.1 Otis Air National Guard Base and the Massachusetts Military Reservation

The Otis ANGB on Cape Cod (Fig. 3.1) includes about 3,540 acres of land. More than 1,600 full-time and part-time personnel work at the base. Otis ANGB is part of the Massachusetts Military Reservation, which comprises more than 20,000 acres, much of it owned by the Commonwealth of Massachusetts and leased to various federal agencies. The agencies that independently operate various portions of the reservation include the Massachusetts ANG, Massachusetts ARNG, U.S. Air Force, U.S. Coast Guard, and the Veterans Administration. The areas managed by each are shown in Fig. 3.2 and listed in Table 3.1.

Camp Edwards, which is used by the Massachusetts ARNG for training activities, occupies approximately 70% of the reservation. The extent of current and proposed ARNG training activities is described in the Master Plan for the Camp Edwards Military Reservation (Massachusetts Army National Guard, 1984). The ANG and Air Force use approximately 17% of the reservation for the Otis ANGB (Fig. 3.3) and a radar station. The U.S. Coast Guard uses 7% of the reservation for communications and search and rescue missions. The remaining 6% of the reservation is used for a Veterans Administration Cemetery and other governmental activities. Many abandoned buildings are located within the cantonment area of Camp Edwards and the Otis ANGB as a result of previous curtailment of military activities.

3.1.2 Adjacent Towns and the Surrounding Region*

The four Upper Cape Cod towns of Bourne, Falmouth, Mashpee, and Sandwich surround the base. These are 4 of the 15 Cape Cod towns in Barnstable County.

Barnstable County

Barnstable County has a land area of more than 400 mi^2 and in the 1980 Census had a permanent population of 147,925 people (U.S. Census Bureau, 1983). Seasonally, the population swells with summer residents and vacationers. The estimated 1985 county population was more than 167,000 people, with a summer population totaling almost 495,000. Two highway bridges at Bourne and Sagamore extend across the Cape Cod Canal to connect the Cape to the rest of the state. Major highway routes on the Cape include State Route 28 and U.S. Route 6. The county has many historic and natural

*Discussions in this section are based principally on Cape Cod Planning and Economic Development Commission, 1985, undated-a, and undated-e.

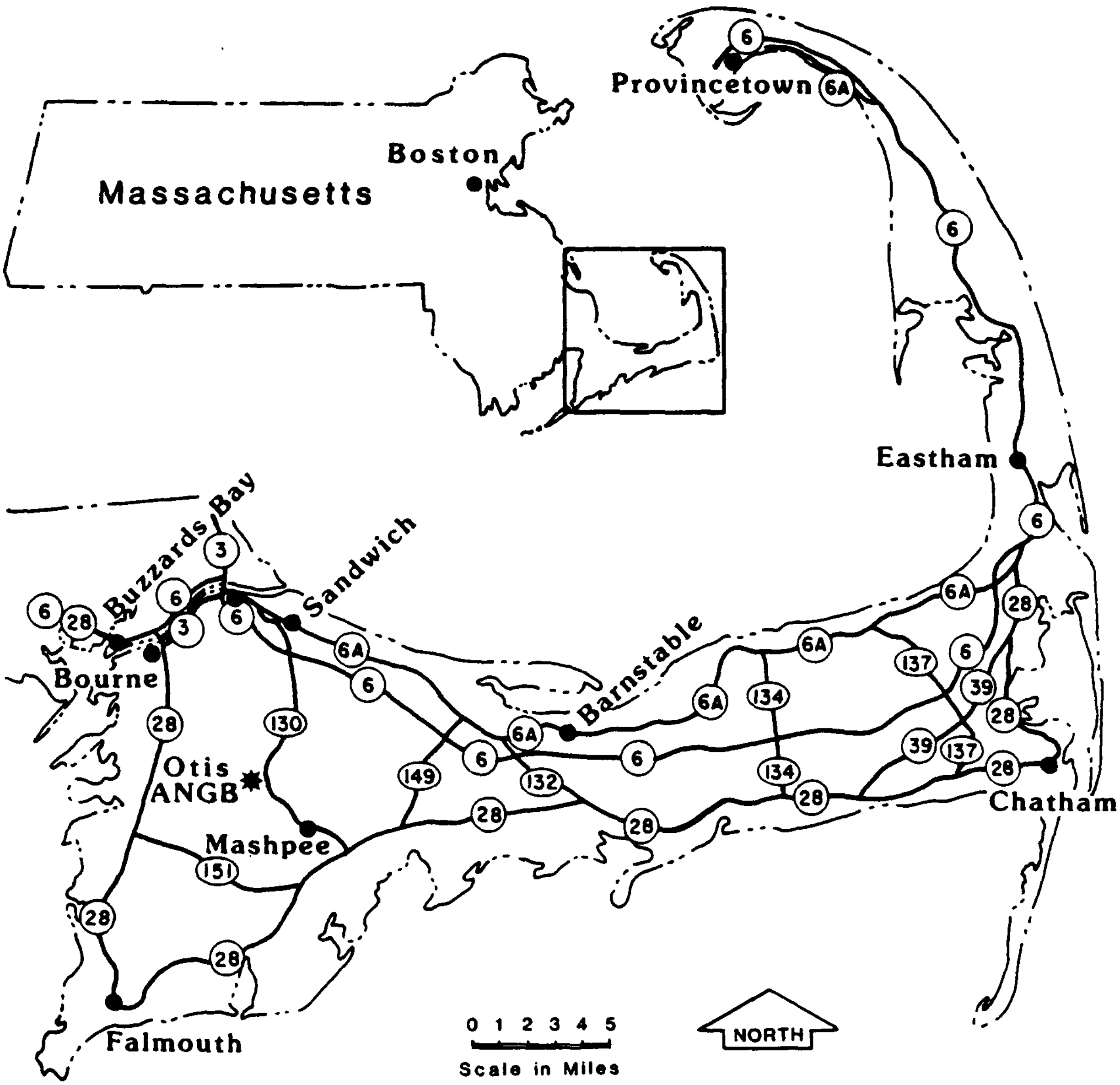


FIGURE 3.1 General Location of Otis ANGB on Cape Cod

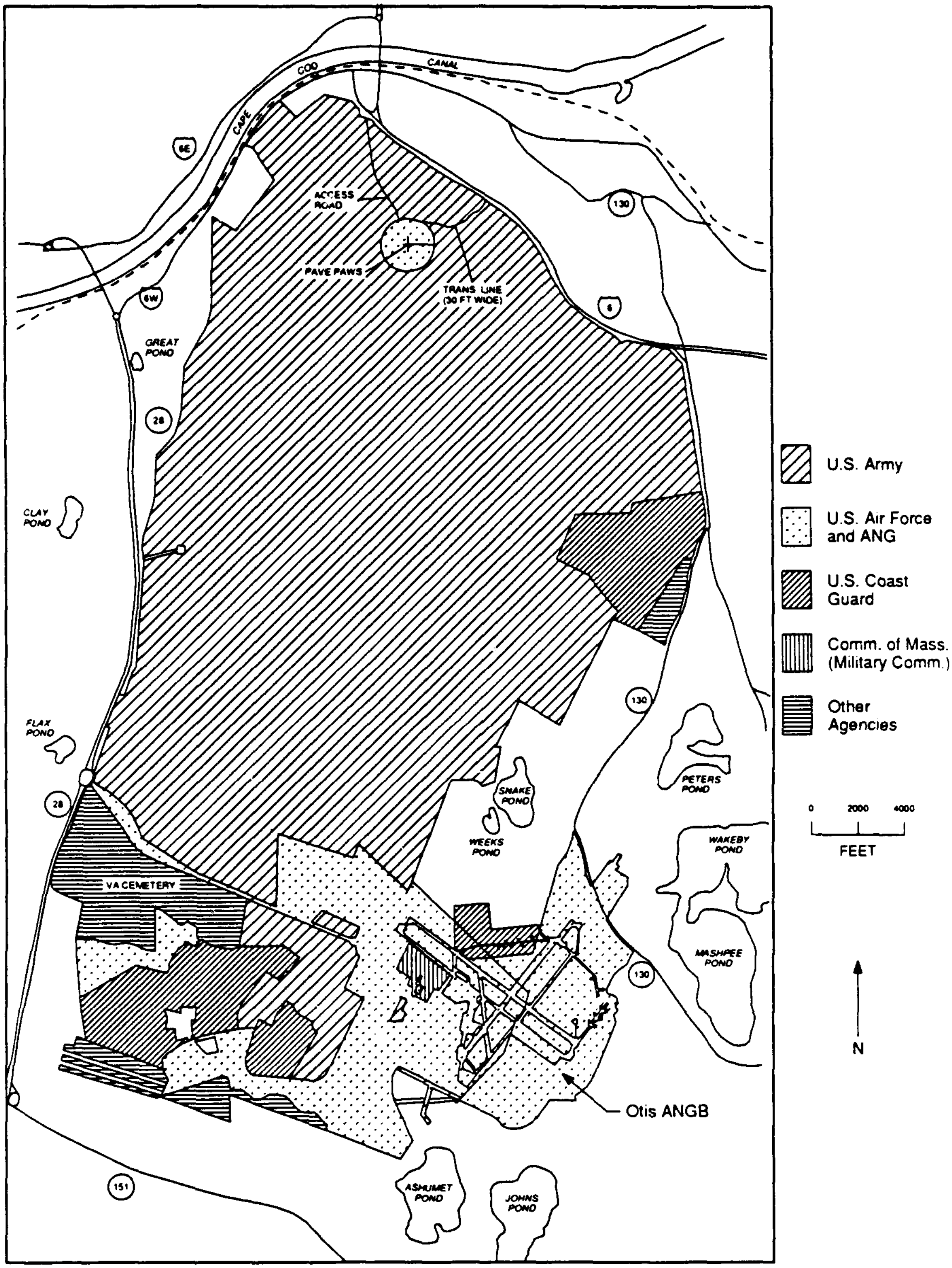


FIGURE 3.2 Massachusetts Military Reservation (Source: Adapted from Massachusetts Army National Guard Map, 1977)

TABLE 3.1. Land Use Management at the Massachusetts Military Reservation

Managing Agency	Acreage	Major Use
Massachusetts Army National Guard	14,705	Training maneuvers & firing range (Camp Edwards)
U.S. Air Force and Air National Guard	3,540	Airfield (Otis ANGB) and radar station
U.S. Coast Guard	1,407	Communications and air station
Veterans Administration	750	Cemetery
Other agencies	513	Miscellaneous activities
Total	20,915	

Source: Adapted from Massachusetts Army National Guard, 1984.

features of note, including the 27,000-acre Cape Cod National Seashore. Tourism and recreation are major components of the local economy.

Town of Bourne

Bourne is located on the western edge of the Cape. The town has a land area of 41 mi^2, nearly 40% (10,283 acres) of which is part of the Massachusetts Military Reservation. In 1985 Bourne was estimated to have a permanent population of 14,900 and a seasonal population of 35,913.

Town of Falmouth

Falmouth is on the southwestern edge of Cape Cod and has a land area of about 45 mi^2. The community of Falmouth is the commercial center for the Upper Cape area. In 1985 the Town of Falmouth was estimated to have a permanent residential population of 25,823 and a seasonal population of 65,302. Route 28 is the most heavily traveled road in the town, with portions of the route at or near traffic volume capacity during the summer months. Route 151 extends east-west through the town and is adjacent to the Crane Wildlife Management Area.

SEE ADJACENT FOLDOUT MAP ----->

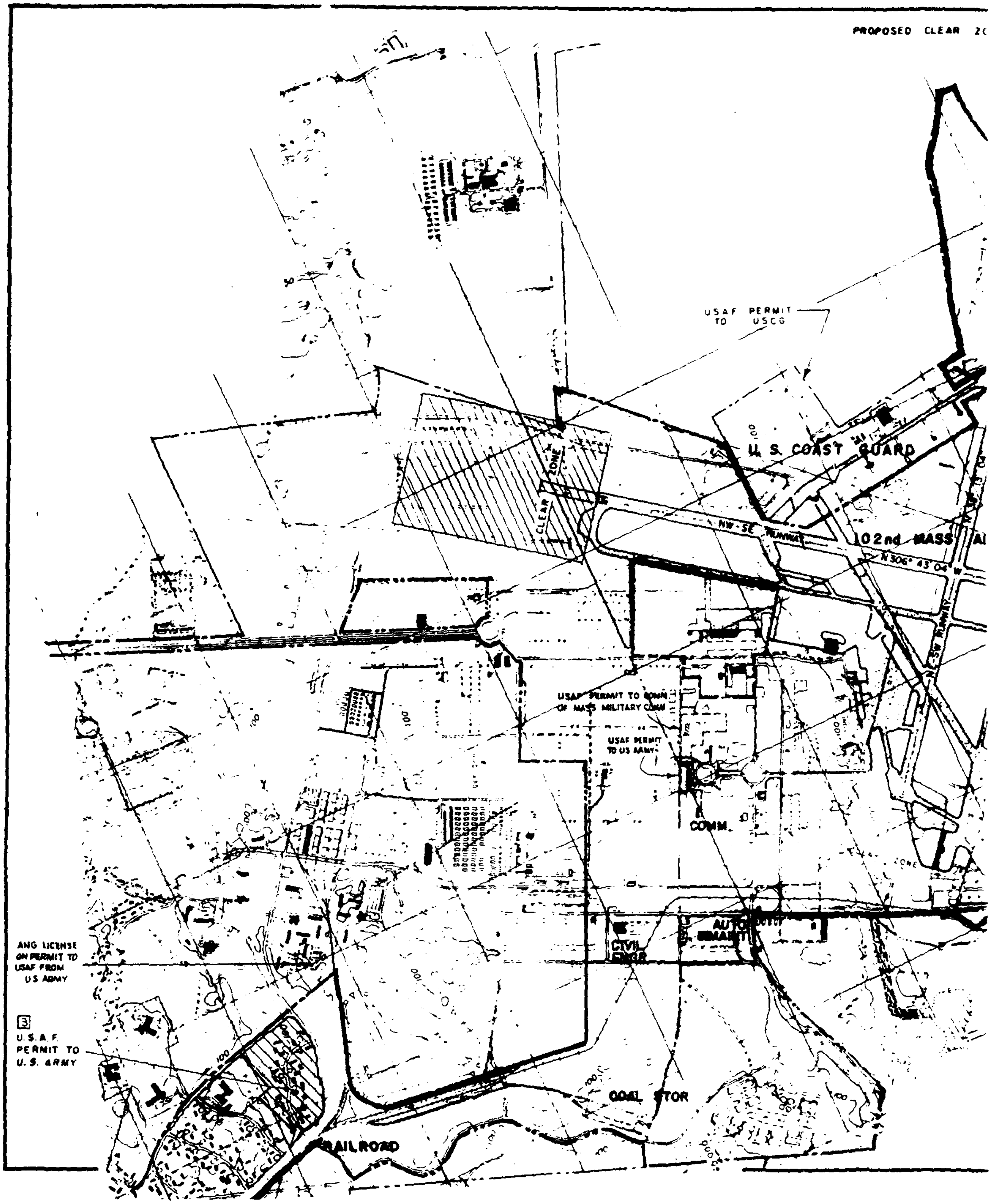
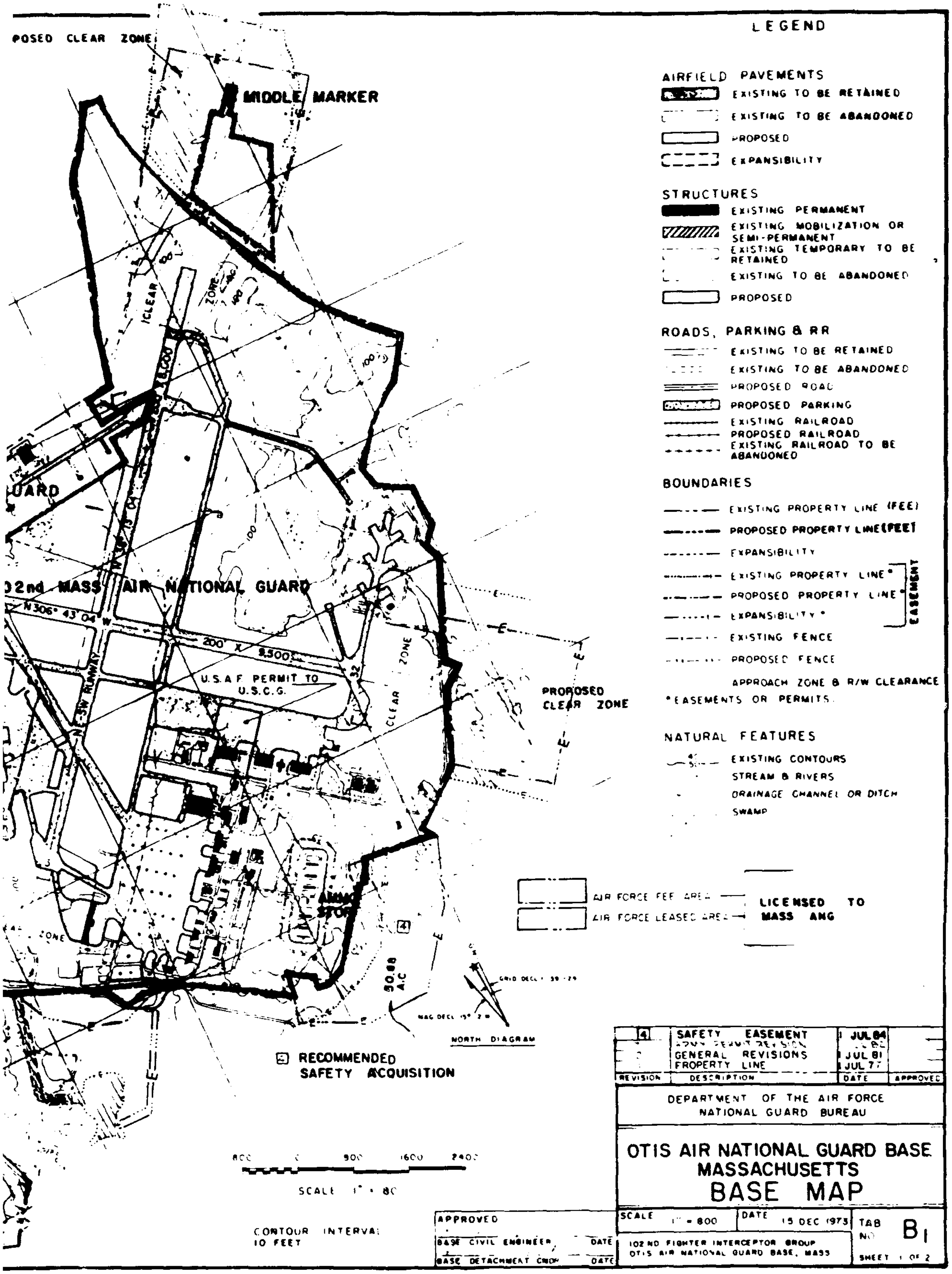


FIGURE 3.3 Layout of Otis ANGB (Source: Massachusetts Air National Guard Base Map, 1973, with revisions through 1984)


POSED CLEAR ZONE
MIDDLE MARKER
UARD
02nd MASS AIR NATIONAL GUARD
N306° 43' 04" W
200' X 8,500'
U.S.A.F. PERMIT TO
U.S.C.G.
PROPOSED
CLEAR ZONE
CLEAR
ZONE
30.88
A.C
RECOMMENDED
SAFETY ACQUISITION
NORTH DIAGRAM
SCALE 1" = 800'
CONTOUR INTERVAL
10 FEET
LEGEND
AIRFIELD PAVEMENTS
EXISTING TO BE RETAINED
EXISTING TO BE ABANDONED
PROPOSED
EXPANSIBILITY
STRUCTURES
EXISTING PERMANENT
EXISTING MOBILIZATION OR SEMI-PERMANENT
EXISTING TEMPORARY TO BE RETAINED
EXISTING TO BE ABANDONED
PROPOSED
ROADS, PARKING & RR
EXISTING TO BE RETAINED
EXISTING TO BE ABANDONED
PROPOSED ROAD
PROPOSED PARKING
EXISTING RAILROAD
PROPOSED RAILROAD
EXISTING RAILROAD TO BE ABANDONED
BOUNDARIES
EXISTING PROPERTY LINE (FEE)
PROPOSED PROPERTY LINE (FEE)
EXPANSIBILITY
EXISTING PROPERTY LINE*
PROPOSED PROPERTY LINE*
EXPANSIBILITY*
EASEMENT
EXISTING FENCE
PROPOSED FENCE
APPROACH ZONE & R/W CLEARANCE
*EASEMENTS OR PERMITS
NATURAL FEATURES
EXISTING CONTOURS
STREAM & RIVERS
DRAINAGE CHANNEL OR DITCH
SWAMP
AIR FORCE FEE AREA
AIR FORCE LEASED AREA
LICENSED TO MASS ANG
4 SAFETY EASEMENT JUL 84
GENERAL REVISIONS JUL 81
PROPERTY LINE JUL 77
REVISION DESCRIPTION DATE APPROVED
DEPARTMENT OF THE AIR FORCE
NATIONAL GUARD BUREAU
OTIS AIR NATIONAL GUARD BASE
MASSACHUSETTS
BASE MAP
APPROVED
BASE CIVIL ENGINEER DATE
BASE DETACHMENT CMDR DATE
SCALE 1" = 800
DATE 15 DEC 1973
102 ND FIGHTER INTERCEPTOR GROUP
OTIS AIR NATIONAL GUARD BASE, MASS
TAB NO. B1
SHEET 1 OF 2

973,

2

Town of Mashpee

Mashpee is east of Falmouth along the southern shore of the Cape. The town has a land area of about 24 mi^2. In 1985 Mashpee had a permanent population of 5,200 and a seasonal population of 21,464. Major roads through the town include Routes 28, 130, and 151. Johns Pond Park is located in the western portion of the town adjacent to the Otis ANGB.

Town of Sandwich

Sandwich, located in the Upper Cape area, has a land area of about 43 mi^2. In 1985 the town was estimated to have a permanent population of 10,768 and a seasonal population of 25,581. Major highways include Routes 6, 6A, and 130.

3.1.3 Cape Cod Environment

Cape Cod is a 440-mi^2 peninsula that extends into the Atlantic Ocean (Fig. 3.1). The Cape is composed of unconsolidated sand and gravel intermixed with some silt, clay, and till. The soil and sediment composition of this peninsula allows rapid infiltration of precipitation, and the groundwater forms a lens above impermeable bedrock that occurs at depths ranging between 80 and 900 ft below sea level. The U.S. Environmental Protection Agency (U.S. EPA) has designated the groundwater as a sole-source aquifer that is utilized by more than 100 municipal wells and thousands of private wells. Because of the highly permeable nature of the unconsolidated deposits in which the groundwater occurs, this aquifer is highly susceptible to contamination by hazardous wastes.

The nutrient-poor and droughty soils of the Cape support a pine-scrub oak vegetation community; the natural vegetation that remains on the Cape provides habitat for a variety of wildlife. In addition, the Cape is an important stopover refuge for millions of waterfowl during fall and spring migration. However, rapid commercial and residential development on the Cape threatens to destroy the remaining natural habitat that is not government owned.

3.2 ENVIRONMENTAL SETTING

3.2.1 Air Quality

Otis ANGB is located in the Southeastern Massachusetts Air Quality Control Region (AQCR 120). The weather fluctuates regularly from fair to cloudy to stormy conditions, ensuring an adequate amount of precipitation. The Cape is in a zone of prevailing west to east atmospheric flow. Although winds of 30 mph or higher may be expected on at least one day every month, gales are both more common and more severe in winter. The ocean has a moderating influence on temperature extremes of winter and summer.

Air quality data collected in 1984 for AQCR 120 indicate that the region is classified as in attainment (in compliance with regulations)* with respect to all air pollutants except ozone (O_3). During the summer, the influx of automobiles to the Cape Cod area is the primary cause of the violations of ozone standards that have been observed. During 1984, the ozone standards were exceeded on four occasions at Attleboro, four at North Easton, nine at Fairhaven, and one at Newburyport. The Fairhaven location is the closest air quality sampling station to Otis ANGB that is operated by the Commonwealth of Massachusetts. For ozone, the maximum reading in 1984 was 0.206 parts per million (ppm), whereas the standard is 0.125 ppm. No sampling stations have been placed at Otis ANGB; however, it is expected that air quality is better there than at the city locations where the state usually places its sampling stations.

All other pollutants in the Otis area are within state primary and secondary standards. For sulfur dioxide (SO_2), the maximum 24-h measured value at Fairhaven was 109 $\mu g/m^3$, compared with the standard of 365 $\mu g/m^3$. The 3-h maximum measured was 164 $\mu g/m^3$, and the secondary standard is 1,300 $\mu g/m^3$. The closest sampling station for total suspended particulates (TSP) is at New Bedford. The measured maximum 24-h concentration was 73 $\mu g/m^3$, compared with the secondary standard of 150 $\mu g/m^3$. The annual average TSP concentration for 1984 was 40 $\mu g/m^3$, compared with the standard of 75 $\mu g/m^3$. For nitrogen dioxide (NO_2), the closest measurement station is at Fall River. The annual average for 1984 was 28 $\mu g/m^3$, whereas the standard is 100 $\mu g/m^3$. There are no carbon monoxide (CO) monitors in AQCR 120.

3.2.2 Noise

General

On a national basis, noise from jet aircraft operations has been a concern for many years. The acoustic energy generated by aircraft can be irritating to people in the general vicinity of airports and air bases. Existing noise sources at Otis ANGB include training operations with F-106, T-33, one C-12 aircraft, and transient aircraft not based at Otis ANGB. Operations of the Massachusetts ARNG at nearby Camp Edwards involve helicopters and gunfire from small arms, mortar, howitzers, and demolition activities. In addition, Coast Guard activities on the reservation involve the use of fixed-wing aircraft and helicopters. The following sections address the existing noise impact of jet flights on the community and the combined impact of the jet and helicopter broadband noise and the impulsive noise from gunfire.

*The Commonwealth of Massachusetts air quality standards are identical to the federal National Ambient Air Quality Standards (NAAQS).

Frequency of Flight Operations

The following evaluations of existing noise impacts were based on the runway utilization pattern presented in Table 3.2 and the numbers of flight operations* given in Table 3.3 for the assigned and transient aircraft using Otis ANGB. The assigned fixed-wing aircraft average 10 sorties‡ per day for the F-106, 1 sortie per day for the T-33, 0.5 sortie per day for the C-12, 0.5 sortie per day for the Army U-8, and 5 sorties per day for the Coast Guard HU-25. On average, there are three closed patterns§ per sortie for the ANG F-106 and T-33 aircraft and two closed patterns per sortie for the Coast Guard HU-25 aircraft. The two types of ARNG helicopters (UH-1H and OH-6A) average a combined total of 3 sorties per day; the Coast Guard helicopters (HH-3F) average 22 sorties per day.

TABLE 3.2 Runway Utilization at Otis ANGB

Runway Number	ANG Operations (%)	Coast Guard Operations (%)
32	50	70
23	30	10
05	15	10
14	5	10

Noise Environment

To provide baseline conditions representing existing aircraft operations at Otis ANGB, noise contours were prepared using the Air Force NOISEMAP methodology. The resulting noise exposure estimate is expressed in terms of the day-night average sound level (L_{dn}) noise contours. This methodology takes into account the effect of an aircraft single event (source noise, altitudes, and airspeed), how many times such events occur during a 24-h period, and the time of day that they occur. L_{dn} is the 24-h average sound level, in decibels (dB), for the period from midnight to midnight, obtained after addition of 10 dB to sound levels occurring during the night (from 10:00 p.m. to 7:00 a.m.). The NOISEMAP methodology uses the following flight data: aircraft type, altitude profiles, thrust/power schedules, flight track locations, number of operations per track, runway utilization schedule, and runup (ground testing) data. Appendix A describes the L_{dn} methodology as it relates to NOISEMAP.

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*A flight operation is a landing or takeoff; e.g., each touch-and-go equals two flight operations.

‡A sortie is an individual flight; it consists of a departure, an approach, and one or more closed patterns.

§A closed pattern is a flight path about the airfield in which the endpoint of the pattern is the same as the starting point.

TABLE 3.3 Existing Average Daily Aircraft Operations at Otis ANGB

Aircraft Type	Departures	Arrivals	Closed Patterns	Takeoffs	Landings	Total Operations
Fixed-wing (assigned)						
F-106	10	10	30	40	40	80
T-33	1	1	3	4	4	8
HU-25	4.85	4.85	10	14.85	14.85	29.7
HU-25 (nighttime)	0.05	0.05	0.1	0.15	0.15	0.3
C-12	0.5	0.5	0	0.5	0.5	1.0
U-8	0.5	0.5	0	0.5	0.5	1.0
	Fixed-wing operations subtotal					120.0
Helicopter (assigned)						
UH-1H	1.8	1.8	13.9[a]	15.7[a]	15.7[a]	31.4[a,b]
OH-6A	1.1	1.1	10.2[a]	11.3[a]	11.3[a]	22.6[a,b]
HH-3F	21.7	21.7	0	21.7	21.7	43.4
HH-3F (nighttime)	0.3	0.3	0	0.3	0.3	0.6
	Helicopter operations subtotal					98.0
Transient						
A-7	0.1754	0.1754	0	0.1754	0.1754	0.3508
A-10	0.0492	0.0492	0	0.0492	0.0492	0.0984
C-7	0.0440	0.0440	0	0.0440	0.0440	0.0880
C-9	0.0412	0.0412	0	0.0412	0.0412	0.0824
C-12	0.2520	0.2520	0	0.2520	0.2520	0.5040
C-21	0.0960	0.0960	0	0.0960	0.0960	0.1920
C-130	0.1726	0.1726	0	0.1726	0.1726	0.3452
KC-135	0.0248	0.0248	0	0.0248	0.0248	0.0496
F-4	0.1372	0.1372	0	0.1372	0.1372	0.2744
F-14	0.0164	0.0164	0	0.0164	0.0164	0.0328
P-3	1.0620	1.0620	0	1.0620	1.0620	2.1240
T-33	0.0574	0.0574	0	0.0574	0.0574	0.1148
T-37	0.2222	0.2222	0	0.2222	0.2222	0.4444
T-42	0.0796	0.0796	0	0.0796	0.0796	0.1592
	Transient operations subtotal					4.8600
Total Existing Operations (F-106 Scenario)						223

[a]ARNG helicopter flight operations include hovering movements 3 to 5 ft AGL, which are included in the individual operations logged.

[b]Approximately 40% of these ARNG flight operations occur in the Camp Edwards R4101 Training Area.

The noise contours as predicted by NOISEMAP for the current level of airfield activity are shown in Fig. 3.4. These contours define the areas of noise levels around the airfield for L_{dn} = 65, 70, 75, 80, and 85. The values on the noise contours can be interpreted to represent different levels of human reaction and are often used as guidelines for zoning by communities in the vicinity of airports and air bases.

The Federal Interagency Committee on Urban Noise, which includes the Air Force and the Department of Housing and Urban Development, considers L_{dn} levels below 65 dB compatible with residential land use. Residential use is discouraged for areas with noise levels between 65-70 dB on the L_{dn} scale, strongly discouraged for areas between 70-75 dB L_{dn}, and unacceptable for areas that exceed 75 dB L_{dn}.

Inspection of the contours in Fig. 3.4 indicates that most of the area within the 65-dB contour lies within the Massachusetts Military Reservation. Only 32 residences (housing approximately 79 people) are within this contour outside the military reservation, all in the vicinity of the Runway 05 centerline near Pimlico Pond. Most of the noise effects at these residences are caused by F-106 aircraft departing from Runway 05. No off-site residences are within the contours of 70 dB or higher.

Noise-Complaint History

The Chief of Airfield Management is designated as the investigating officer for all noise complaints at Otis ANGB. A complaint log is maintained listing the name of the complainant, the nature of the complaint, and the time and date the complaint is received. The log also notes the action taken, which can vary from a phone call to a personal visit and corrective action to prevent a similar problem in the future. The 1985 log lists 20 complaints, and the 1986 log shows 22 noise complaints. There were five complaints during the period January 1 to April 30, 1987. The most common cause of complaints is the weekend exercises during the summer. The increase in temporary residents during the summer is a factor since these individuals may not be accustomed to jet noise. The noise complaints are minimal during October through February and increase during the spring and summer seasons when windows are more likely to be open and people are outside. The NOISEMAP contours provide an indicator of potential community annoyance due solely to aircraft noise.

Noise-Abatement Procedures

The F-106 is powered by a turbine engine equipped with an afterburner. The afterburner is used for relatively short periods to generate additional engine thrust. Standard military takeoff procedures for the F-106 require the use of the afterburner from the time the aircraft begins its takeoff roll until it reaches an airspeed of 250 knots, in a specific takeoff-climb configuration. The afterburner usually is deactivated about 9,000 ft from the departure end of a runway, at an altitude of 300-500 ft above airport elevation. The first noise-abatement procedure is to deactivate the F-106 afterburner as soon as practical. The F-106 pilots terminate use of afterburners (108% power) at 250 knots, accelerate at full military power (101%) to 310 knots, and

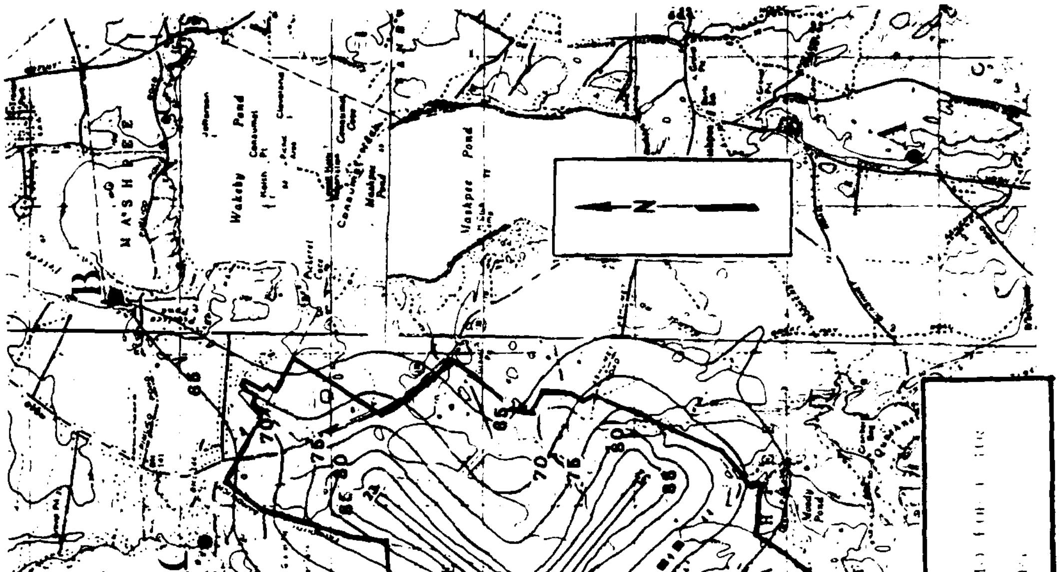

FIGURE 3.4 Noise Contours for F-106 Flight Operations

maintain this climb speed at reduced power (95%) for noise abatement reasons through 5,000 ft mean sea level (MSL) prior to accelerating to 400 knots at military power. This takeoff procedure is used unless otherwise indicated by traffic control. This procedure gets the aircraft up and out of the airport control area through 5,000 feet considerably more quickly than does the standard takeoff procedure for the F-106. The standard procedure involves the use of military power (after deactivation of the afterburner at 250 knots) to reach a speed of 400 knots. That procedure involves a low rate of climb and a high power setting, both of which would not be conducive to reducing noise levels on the ground at Otis.

Several additional measures are used to minimize noise impact of the Otis ANGB operations. First, upon takeoff, the jets do not turn until they have passed the Barnstable County Hospital, which is located to the left of the centerline of Runway 32. Second, left-hand traffic is established for Runway 05 to preclude flyovers of the John's/Ashumet Pond area. All departing fixed-wing aircraft climb straight ahead to 1,300 ft MSL before turning out of traffic. This is done to preclude turns over base housing and off-base areas adjacent to the ends of the runways. Third, the F-106 aircraft maintain a lower airspeed of 250 knots (vs. 325 knots) in the traffic pattern, thus reducing noise emissions in this phase of flight. Fourth, except during approach and landing, the F-106 aircraft maintain a minimum 5,000-ft altitude on all flights over the Cape and islands. Finally, a hush house was installed to eliminate engine maintenance runup noise. The building is on the northern side of the main ANG ramp.

Combined Impact of ARNG Gunfire and ANG Jet Noise

It is common for residents in the vicinity of the Massachusetts Military Reservation to hear artillery fire at the same time that jet aircraft or helicopter activity occurs. The basic noise issue here is whether the aircraft and gunfire noises are actually additive in their effects or whether one type of noise masks the other. Two analyses were conducted to evaluate the potential combined impact. Appendix B describes the details of the study; only the major results are presented here.

The first method of analysis follows U.S. Army and Department of Defense policy documents (Department of the Army, 1982; Metcalf, 1977). This technique involves the addition of (1) day-night levels of noise predicted for ARNG activities (based on C-weighting, as described in Appendix B) for a typical (annual average) day of activities, and (2) day-night levels of noise predicted for ANG jet flying activities (based on A-weighting) for a typical day. Day-night noise levels for ARNG activities were computed by the Army Environmental Hygiene Agency using the BNOISE Model for the year 1990. Day-night noise levels for a typical day for ANG activities were computed using NOISEMAP. The isopleths predicted by the two models were summed in accordance with the Army policy recommendation (Department of the Army, 1982). The results indicated that the overlap of the critical isopleths (62 dB [C-weighting] for ARNG and 65 dB [A-weighting] for ANG/Coast Guard) occurs over a very small area northwest of the Otis ANGB. The area of overlap is completely within the boundary of the Massachusetts Military Reservation.

The second method of analysis involved evaluation of impacts of peak noise events related to operations of the ARNG and ANG by determining the relative contributions to the total noise caused by jet aircraft, ARNG and Coast Guard helicopters, and ARNG gunfire and demolitions. Eleven noise-sensitive areas (each with the potential for occasional maximum noise levels due to ARNG activities, ANG activities, Coast Guard activities, or possibly from activities of all three groups) were chosen for study. The activity scenarios modeled represented ARNG activities with ANG/Coast Guard jet activities and ARNG/Coast Guard helicopter activities superimposed. These activities are described in detail in Appendix B, Secs. B.1 and B.3.1. The measure of noise level used for comparison was the perceived magnitude (loudness) of the individual sounds as heard outdoors. Research data are insufficient to compare the relative annoyances of these sources. The analysis does not include indoor annoyance because people's reaction to indoor low-frequency noise (produced by impulsive sources such as Army ordnance) is primarily influenced by induced structural vibration (Schultz, 1982), especially if sufficient to rattle glassware, pictures, etc. Such modeling would have to be done individually for each residence and is beyond the scope of the current work. As a result, noise modeling is done for individuals assumed to be outdoors.

The basic conclusion of this study of maximum noise events is that one type of sound (jets or helicopters) generally dominates or is dominated by the impulsive noise (demolition or gunfire), depending on the relative location of the noise sources with respect to the receptor. For example, at Bourne/Route 6W (near Jefferson Road), the noise of howitzer fire masks the noise of F-106 aircraft operations. On the other hand, howitzer fire is masked by the noise of F-106 departures from Runway 05 for Sandwich residences near Pimlico Pond. Noise levels from the ARNG and ANG activities are not additive in a significant way at any of the 11 community locations. Because of the time-dependent nature of these noise sources, only loudness values at their maximum impacts are compared. These comparisons are discussed in greater detail in Appendix B.

3.2.3 Training Airspace

The 102nd FIW uses a number of low-altitude, high-speed training routes to perform its training mission with the F-106 aircraft. The Massachusetts ANG uses low-flying routes in Maine and New Hampshire (VR 841) and in Canada for low-level overland navigational training at altitudes as low as 300 ft AGL (and up to 3,000 ft AGL) at speeds varying from 350-600 knots. Low-level flying operations also are conducted over the Atlantic Ocean, but the aircraft are required to stay at least 1,000 ft above the water. Such routes are used to provide realistic training in high-speed, low-altitude navigation techniques designed to intercept low-flying enemy aircraft. After takeoff, the ANG pilots fly their F-106 aircraft at high altitude enroute to the low-level areas and then perform low-altitude exercises along the prescribed routes.

The 102 FIW performs intercept training in airspaces both over land and over water. The over-land airspaces are above the states of Maine, New Hampshire, and Vermont. They are designated as Laser (18,000-50,000 ft MSL), Condor (7,000-18,000 ft MSL), Yankee (9,000-18,000 ft MSL), and Scoty (18,000-60,000 ft MSL). The over-water

airspaces are over the Atlantic Ocean; they are designated as Warning Area 105 (surface - 60,000 ft MSL), Warning Area 102 (Surface - 60,000 ft MSL), and MOT A, B, C, D (surface - 60,000 ft MSL). Here again, the ANG pilots fly their F-106 aircraft at high altitude after takeoff from Otis ANGB, then they perform intercept training in the prescribed areas within the authorized blocks.

3.2.4 Hazardous Materials

General

A number of hazardous wastes are routinely transferred from the Otis ANGB to the Defense Logistics Agency (DLA). Small volumes of such items as nickel-cadmium batteries, lead-acid batteries, acids, paints, paint-strippers, hydraulic fluids, and photographic chemicals are routinely discarded. The largest volume consists of waste fuels, fuel oils, lubricating oils, and cleaning solvents. About 5,200 gal (390,000 lb) of such wastes have been generated annually in recent years.

Hazardous wastes are handled at Otis ANGB in accordance with the Commonwealth of Massachusetts regulations 310 CMR 30, U.S. EPA regulations in 40 CFR, and ANG regulations 19-1, 19-11, and AFR 19-14. The wastes are collected at a designated central collection point on the base -- Bldg. 204. Storage of any waste at this area awaiting pickup by the DLA is limited to 90 days. The approximate volumes of these materials and the procedures for handling them would be the same after the aircraft conversion.

Asbestos

Asbestos is possibly present in some of the buildings on the military reservation. The alert facility and Bldg. 165 have been identified as buildings affected by this proposed conversion that contain asbestos.

3.2.5 Herbicides and Pesticides

Herbicides have been routinely applied by base personnel to control vegetative growth at the edge of runways. Pesticides have been routinely applied by licensed contractors to limit destruction and annoyance caused by rodents and insects. These materials are currently applied by a licensed contractor in accordance with state and federal regulations.

3.2.6 Water Resources

Fresh water found in Pleistocene sand and gravel deposits supplies nearly 100 municipal and thousands of private wells on Cape Cod. All of Cape Cod is designated as a sole-source aquifer by the U.S. EPA, and recharge to this aquifer is by precipitation,

treated sewage effluent, and septic effluent. There is no flowing surface water on the Massachusetts Military Reservation. The Camp Edwards portion of the reservation is located on the highest (60-80 ft) recharge areas and represents an important area of groundwater recharge to the western half of Cape Cod (Guswa and LeBlanc, 1985).

A water well (J-well) located on Otis ANGB supplies all the water used on the base. Table 3.4 shows the results of a 1986 survey for substances in the EPA's Hazardous Substances List, as well as organic and inorganic parameters mandated by the Safe Drinking Water Act. All values from the samples taken from J-well are below any water quality limits established by the U.S. EPA or the Commonwealth of Massachusetts.

The Otis ANGB wastewater treatment facility is located on a broad sand and gravel outwash plain within the Town of Sandwich at the Falmouth town line. The treatment plant has been in operation since 1936, with the original capacity of 3 million gal per day (gpd) installed in 1941 to serve up to 70,000 troops who were training at the base. Currently, an average of 300,000 gpd (with a peak of 500,000 gpd) flows to the plant (Camp Dresser and McKee, 1985). The discharge permit issued by the Commonwealth of Massachusetts limits maximum discharge levels to 800,000 gpd. Primary treatment involves the use of a comminutor with a bar screen, an aerated grease-removal unit, and Imhoff tanks. Secondary treatment uses trickling filters and settling tanks. The last stage involves land disposal of the treated wastewater in half-acre sand beds (8 total out of the original 24), each designed to handle 125,000 gpd of treated wastes. The beds are about 20 ft above the water table and consist of 1 ft of sand, 2 ft of sandy loam, and 18 ft of medium sand (as cited in Kerfoot and Ketchum, 1974). The treated sewage percolates through the beds to the groundwater.

In 1976, detergents were found in a new municipal well 1.5 mi from the sand beds, prompting a study of the situation by the U.S. Geological Survey (USGS) and the Massachusetts Department of Environmental Quality and Engineering (DEQE), Division of Water Pollution Control (Camp Dresser and McKee, 1985). The study revealed the presence of a contaminated plume of groundwater that originated from the Otis treatment plant and extended at least 11,000 ft south of the treatment facility, with a width of 2,500 to 3,500 ft at a depth of 30 to 90 ft (LeBlanc, 1984).

The contaminated plume contains elevated concentrations of boron (100-410 μg/L, compared with 50 μg/L in the uncontaminated water) that probably originates from detergents and other cleaning agents. Ammonia and nitrate concentrations also exceed those found in the uncontaminated groundwater. Ammonia changes to nitrate in the presence of oxygen and bacteria in the groundwater, and as a result, ammonia is found primarily in the center of the plume where oxygen levels are too low to support nitrification. Total nitrogen in the plume ranges from 1.5 mg/L along the edge to 24 mg/L in the center (LeBlanc, 1984). Concentrations of detergent exceed 0.5 mg/L of methylene blue active substances from 3,000-10,000 ft downgradient of the treatment facility. These concentrations reflect the use of nonbiodegradable detergents at the Massachusetts Military Reservation between 1946 and 1964. Except for phosphorous, which readily binds to the sediment and also forms insoluble phosphorus compounds, the chemical contaminants in the plume appear to be moving with the groundwater at a rate of 0.8-2.3 ft per day (LeBlanc, 1984).

TABLE 3.4 Water Quality Data from J-Well at Otis ANGB[a]

Class/Compound	Range of Concentrations above Detection Limit (μg/L)	Number of Times Detected[b]	Number of Times Exceeding Maximum Contaminant Level	Primary Drinking Water Standards[c]
Volatile organics				
Tetrachloroethylene	1 - 1.1	5	0	5 μg/L[d]
Trichloroethylene	3.8 - 4.0	2	0	5 μg/L[e]
Inorganics				
Lead	5.2 - 9.9	2	0	0.05 mg/L
Mercury	0.26	1	0	0.002 mg/L
Total trihalomethane				
Chloroform	1.0	1	0	0.1 mg/L

[a]Source: E.C. Jordan, Inc. (1987), except as noted.

[b]Number of times out of 17 samples, including samples and duplicates collected over 12 consecutive weeks between April 9, 1986, and June 24, 1986.

[c]U.S. Environmental Protection Agency, 1983.

[d]Currently no proposed standard, but the standard would most likely be 5 μg/L (E.C. Jordan, Inc., 1987).

[e]U.S. EPA proposed maximum contaminant level.

The Massachusetts DEQE issued a discharge permit in October 1984 that required the treatment facility to meet chemical discharge levels that would return the groundwater to drinking water standards (Camp Dresser and McKee, 1985). To comply with the permit requirements, the ANG initiated a study with a consulting firm (Camp Dresser and McKee) to evaluate wastewater treatment alternatives. The consultants developed five treatment alternatives that would meet the requirements of the discharge permit (Camp Dresser and McKee, 1985). Since each alternative would cost about the same, it was recommended that selection of an alternative to the current treatment facility be based on potential effects to groundwater quality and use. An environmental impact statement is being prepared to determine an acceptable alternative to the present disposal of effluent.

Groundwater contamination is being examined as part of the Installation Restoration Program (IRP). The IRP seeks to identify, characterize, and develop remedial solutions for all sources of groundwater contamination on the Massachusetts Military Reservation. Forty-two sites on the reservation have been identified as potential points or areas of contamination.

3.2.7 Land and Soil Quality

The Massachusetts Military Reservation is located in the Coastal Plain physiographic province. The bedrock is overlain by unconsolidated sediments primarily deposited by glacial action. While two hilly areas, defined by the Buzzards Bay Moraine and the Sandwich Moraine, occur along the western and northern boundaries of Camp Edwards, the portion of the reservation occupied by Otis ANGB is relatively flat.

As a result of glacial action, soils on the reservation are primarily sands and gravels mixed with silt, clay, and till. Soils on Otis ANGB are either sand mixed with gravel (Agawam Series) or silty materials overlaying sand and gravel (Enfield Series). The soils have very rapid permeability, and the hydraulic conductivity of the sediments can be as high as 200-300 ft per day (LeBlanc, 1984). This high permeability limits the effects of surface water erosion on the relatively flat terrain of Otis ANGB. However, because of the numerous construction activities that have occurred over the last 50 years, especially in the cantonment area, the natural surface soil structure at Otis ANGB has been altered. Currently, the soils on the undeveloped portion of the base are well protected with managed or natural vegetative cover.

3.2.8 Vegetation and Wildlife Resources

The Massachusetts Military Reservation contains about 17,000 acres of undeveloped land. Most of this land is located on Camp Edwards and represents a significant portion of contiguous habitat for numerous species of plants and animals. The Shawme-Crowell State Forest borders the northern edge of the reservation, and the Crane Wildlife Management Area borders the southern part of the base. Thus, the reservation serves as an important habitat link connecting the two state-owned natural areas.

The well-drained soils on Cape Cod support a pine-oak ecosystem (Whittaker, 1975). Pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) dominate the overstory vegetation, with white oak (*Quercus alba*), red oak (*Quercus rubra*), and pin oak (*Quercus palustrus*) found on more favorable sites. Typical understory vegetation consists of heaths (e.g., blueberry), ferns, and greenbriar.

The extensive areas of natural vegetation on the reservation provide habitat for numerous bird and mammal populations, including ruffed grouse, bobwhite quail, osprey, red-tailed hawk, raccoon, shorttail weasel, woodchuck, and whitetail deer. The presence of these populations is indicative of a landscape that is relatively undisturbed by human activities. Since most of the natural vegetation is located on Camp Edwards, the highest wildlife densities occur in that area of the reservation. In fact, the Massachusetts

Division of Fisheries and Wildlife conducts a deer hunting season on a portion of Camp Edwards each fall. Otis ANGB consists primarily of buildings, runways, and managed vegetation; thus, the base does not support the variety of woodland animal populations found on Camp Edwards.

3.2.9 Threatened and Endangered Species

In the summer of 1984, the Massachusetts Division of Fisheries and Wildlife, Natural Heritage Program, conducted a field survey for rare and endangered plant and animal populations on the Massachusetts Military Reservation. No federally classified threatened or endangered species were found on the reservation, but several rare plant species were found on Camp Edwards. These included sandplain flax (*Linum intercursum*) and two plants located in unnamed ponds near the main entrance to the reservation on Route 28--umbrella-grass (*Fuirena pumila*) and hyssop hedge-nettle (*Stachys hyssopfolia*).

The survey also found three species of birds on Otis ANGB and Camp Edwards that have been classified by the Massachusetts Division of Fisheries and Wildlife as state endangered, state threatened, and a species of special concern. These three species are the upland sandpiper (*Bartramia longicauda*), the northern harrier (*Circus cyaneus*), and the grasshopper sparrow (*Ammodrammus savannarum*), respectively. The locations of these sightings, as reported in a study funded by the ANG (White and Melvin [1985]), are shown in Figs. 3.5 through 3.7. These bird populations depend on the extensive grassland areas that are maintained on Otis ANGB.

3.2.10 Socioeconomic Factors

The Cape Cod area (Barnstable County) had a population of 147,925 persons in the 1980 Census (Table 3.5). The four-town Upper Cape area of Bourne, Falmouth, Mashpee, and Sandwich contains almost 34% of Cape Cod's total population. Between 1970 and 1980, the county experienced a 53% population growth, making it the highest growth region in Massachusetts (Massachusetts Army National Guard, 1985). Although Bourne experienced a population growth of 9.8% from 1970-1980, the other three Upper Cape towns experienced growth rates significantly higher than the county as a whole (Table 3.5).

Because of its natural features, water-related recreational opportunities, and proximity to the greater Boston metropolitan area (1.5-2 h driving time), Cape Cod is a major resort area. The Cape experiences a large seasonal influx of tourists starting in April, peaking in July and August, and ending around November. Also, an increasing number of people are retiring on the Cape. Construction of second homes continues to increase.

Rapid growth of both seasonal tourism and residential and commercial development is expected to continue into the near future. The year-round population of Cape Cod is projected to exceed 230,000 by the year 2000. If one adds to the permanent population a seasonal second-home population of 350,000 and up to 50,000 tourists (residing in hotels, motels, tent/trailer parks, etc.) during peak season, the total peak summer population could easily reach 630,000 persons.

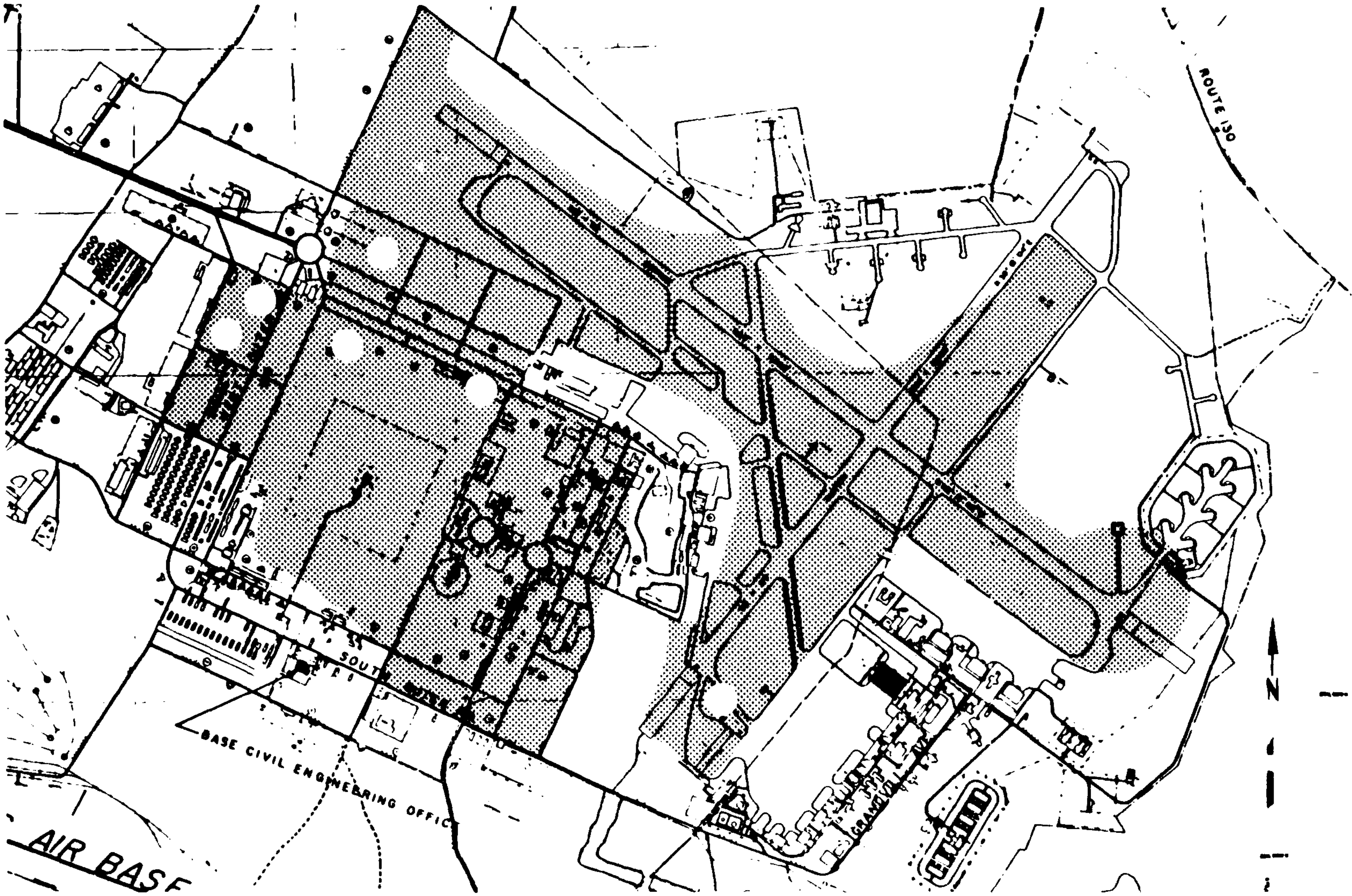

FIGURE 3.5 Location of Nests and Fields Used by Upland Sandpipers (Note: open circles = nests, shaded areas = field areas used for feeding, loafing, courtship, nesting, and brooding at Camp Edwards/Otis ANGB, May-July 1985) (Source: White and Melvin, 1985)

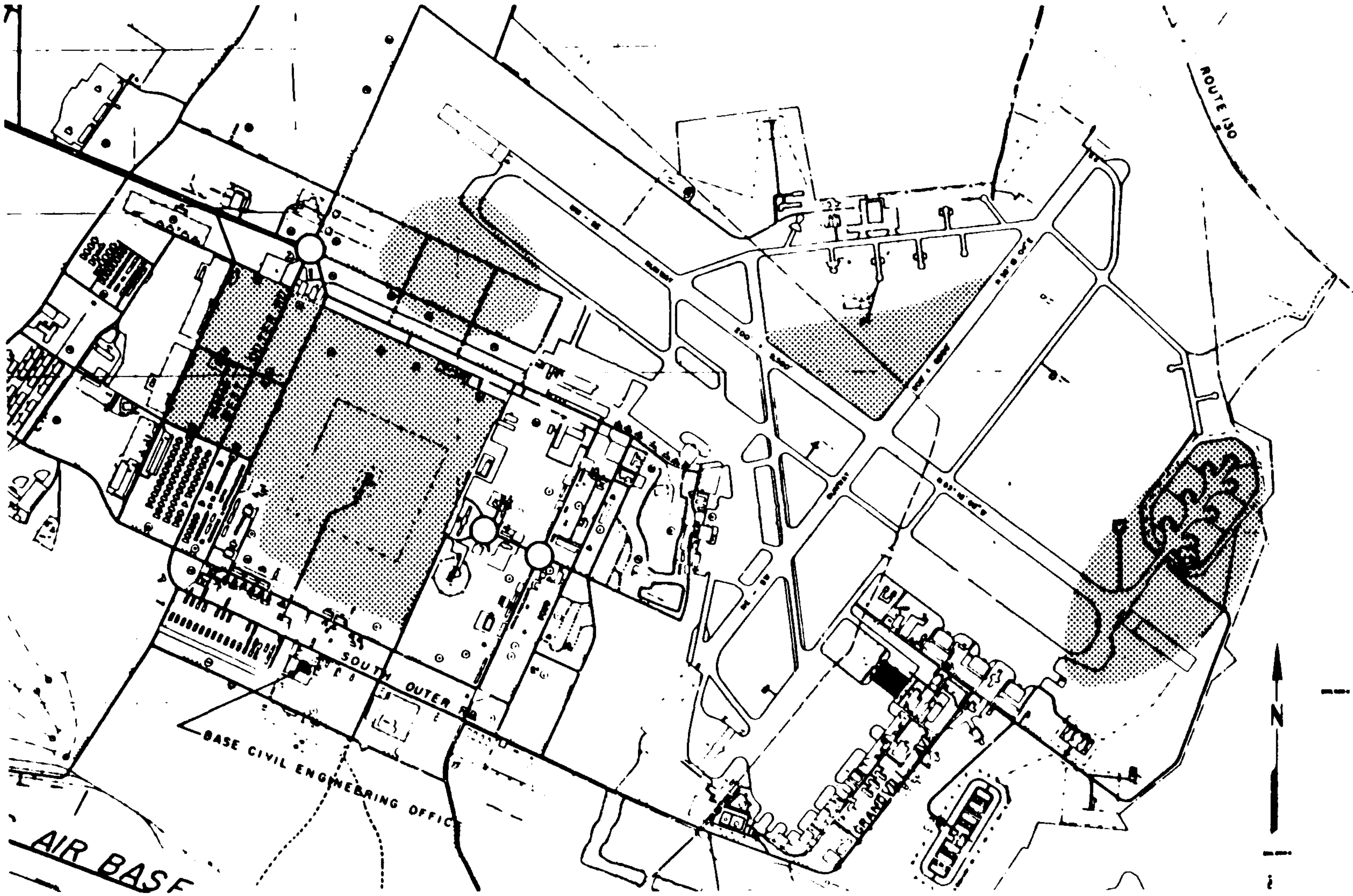

FIGURE 3.6 Location of Areas Used by Resident Pair of Northern Harriers (Note: shaded areas = areas used at Camp Edwards/Otis ANGB, May–July 1985) (Source: White and Melvin, 1985)

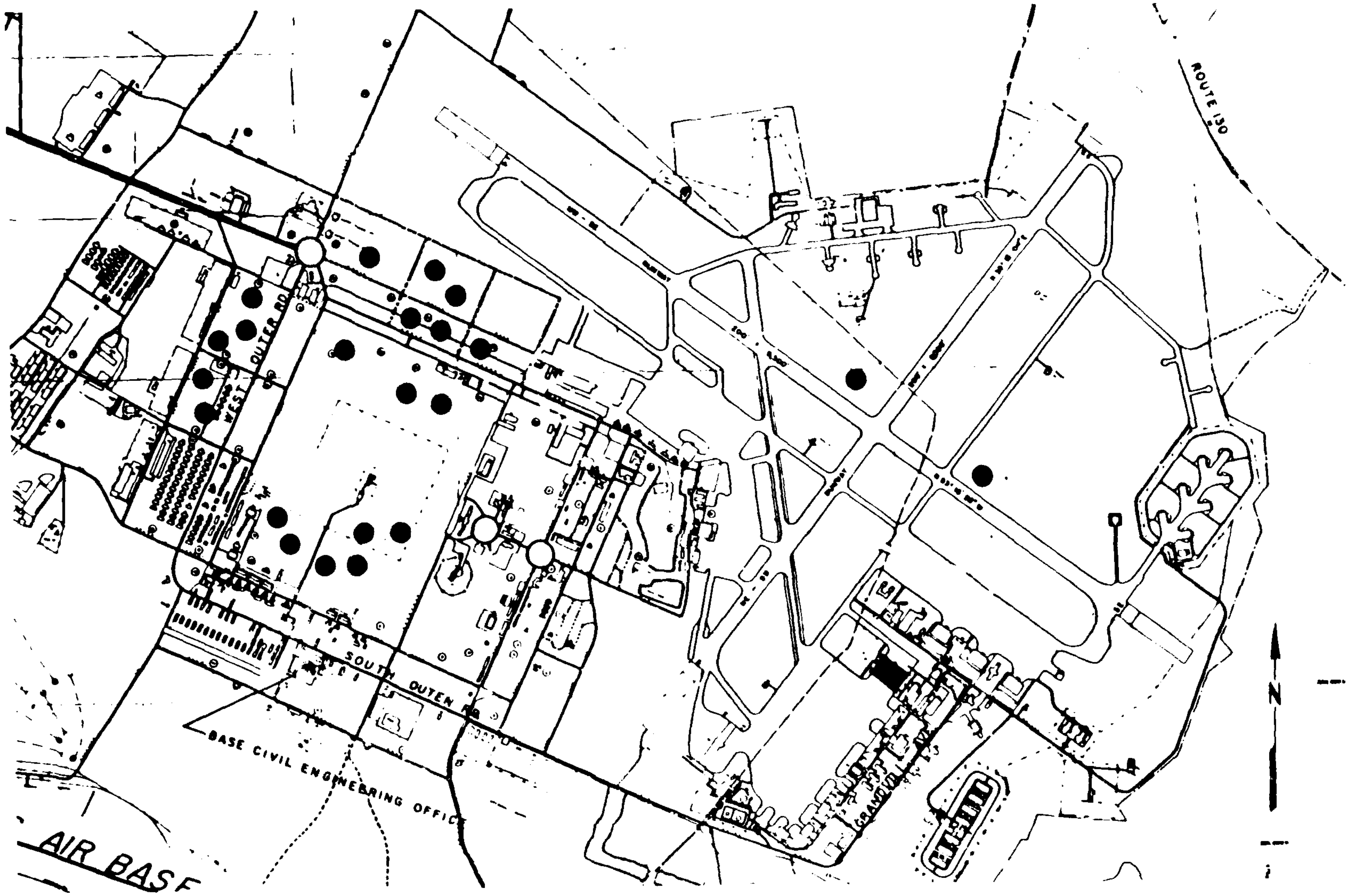

FIGURE 3.7 Location of 22 Territorial Grasshopper Sparrows (Note: Circles = locations at Camp Edwards/Otis ANGB, May-July 1985) (Source: White and Melvin, 1985)

TABLE 3.5 Population Data for Barnstable County and Upper Cape Cod Area[a]

Political Unit	1970[b] Otis ANGB	1970[b] Civilian	1970[b] Total	1980[b] Otis ANGB	1980[b] Civilian	1980[b] Total	Percent Increase, 1970-1980
Barnstable County	5,596	91,060	96,656	2,045	145,880	147,925	53.0
Bourne	3,864	8,772	12,636	2,040	11,834	13,874	9.8
Falmouth	127	15,815	15,942	5	23,635	23,640	48.3
Mashpee	-	-	1,288	-	3,700	3,700	187.3
Sandwich	1,605	3,634	5,239	-	8,727	8,727	66.6

Political Unit	1985[c] Permanent	1985[c] Seasonal	2000[c] Permanent	2000[c] Seasonal	Projected Percent Increase Permanent Population, 1980-2000
Barnstable County	167,000	495,000	230,038	604,449	55
Bourne	14,900	35,913	18,363	42,528	32
Falmouth	25,823	65,302	32,088	76,203	36
Mashpee	5,200	21,464	11,843	34,757	220
Sandwich	10,768	25,581	19,027	37,047	118

[a]Barnstable County contains 15 towns, four of which -- Bourne, Falmouth, Mashpee, and Sandwich -- constitute the Upper Cape Cod area.

[b]Based on 1970 and 1980 U.S. Census data as cited in Cape Cod Planning and Economic Development Commission, undated-c.

[c]From Cape Cod Planning and Economic Development Commission, undated-e.

3.2.11 Cultural Resources

The Upper Cape Cod area is the ancestral home of the Wampanoag Indians. The area was first settled by the Europeans in the early 1600s. Among the several historic sites in the Upper Cape region are historic homes, meeting houses, cemeteries, and Indian burial grounds.

The Massachusetts Historical Commission records only one prehistoric archaeological site located in the Veteran's Administration area and several historical sites located in the northern region of Camp Edwards (Massachusetts Army National Guard, 1985). Although an archaeological and historic reconnaissance survey is currently underway as part of the comprehensive master planning process for Camp Edwards, no survey is planned for the Otis ANGB area. The Massachusetts State Historic Preservation Officer has determined that a survey of the project site area would not be necessary (Talmage, 1986).

3.2.12 Land Use

Table 3.6 shows land uses in the four Upper Cape towns and in Barnstable County as a whole. Although forestland and wetlands still dominate the area for each of the four towns (61-80%), the percentage of land being used for urban purposes (14-26%) has greatly increased over the past 30 years. The amount of land dedicated to urban use is expected to continue to increase as construction of permanent and second-home residences and commercial developments continue.

All four towns have zoning regulations. In the Town of Bourne, zoning adjacent to the military reservation includes residential to the north and scenic development, business, and residential to the west. Along the southern boundary of the reservation, most of the land is zoned for public use, with a small amount zoned for agriculture. In the Town of Mashpee, the southern and eastern boundaries of the military reserve are adjacent to residential development and recreational areas. Much of the reservation boundary in the Town of Sandwich is bordered by land zoned for low- and medium-density residential use, with the remainder zoned for business and industrial purposes. Specific locations of the zoned parcels and the associated allowable uses are detailed in the zoning ordinances and maps of the respective towns.

In September 1980, Otis ANGB published an Air Installation Compatible Use Zone (AICUZ) report (Otis Air National Guard Base, 1980). This report summarized the findings of investigations concerning the need for compatible land use planning between Otis ANGB and its neighboring towns. The AICUZ concept is designed to promote land use development near USAF and ANG airfields in a manner that will not only protect adjacent communities from the noise and safety hazards associated with aircraft operations, but also will preserve the operational integrity of the airfields. The Otis ANGB provides all the towns with the current AICUZ and recommends that the towns incorporate it into their zoning plans.

TABLE 3.6 Land Use (acres) of the Upper Cape Area

	Bourne		Falmouth		Mashpee		Sandwich		County Total	
Classification	1951	1980	1951	1980	1951	1980	1951	1980	1951	1980
Agriculture	1,145	137	4,281	992	420	62	1,396	558	17,135	3,716
Cranberry bogs	232	247	288	308	392	269	192	170	3,530	2,500
Open land	927	1,275	1,200	1,625	182	253	1,572	1,162	21,592	15,393
Wetland	2,524	2,158	3,875	4,033	2,056	2,668	2,284	2,283	45,065	47,203
Forestland	21,326	18,735	19,391	15,061	13,128	10,646	20,940	17,459	173,895	141,832
Disposal	120	149	364	364	47	47	199	221	1,659	1,833
Recreation land	273	295	816	816	313	325	684	709	6,226	6,359
Urban land	1,897	4,955	2,469	8,305	502	2,410	2,100	5,922	19,090	61,471
Total acreage	27,951		31,504		16,680		28,484		280,307	

Source: Adapted from Cape Cod Planning and Economic Development Commission, Undated-d.

Land use within the Otis ANGB and adjacent to the military reservation is described in Sec. 3.1.1. An area located adjacent to the Otis ANGB to the north and west of Moody Pond consists of former sand pits (operated during the 1950s and 1960s) that presently consist of second growth pitch pine (15-20 ft tall) crisscrossed with roads and trails used by four-wheel-drive vehicles and motorbikes (Fundala et al., 1985). The Town of Mashpee owns land in this vicinity and manages it for conservation purposes (e.g., trails and wildlife habitat) to protect it from development. A large portion of this area is presently covered by existing Otis ANGB easements.

3.2.13 Air and Land Traffic

Eight types of military aircraft are assigned to the Massachusetts Military Reservation -- F-106, T-33, C-12, U-8, and HU-25 fixed-wing aircraft; and UH-1H, OH-6A, and HH-3F helicopters. The average numbers of daily operations for these aircraft and for the various transient aircraft that use the base are listed above in Table 3.3. The T-33 aircraft are being phased out and would not be present at the time of the proposed conversion; most C-12 missions will continue to be conducted off station; the HU-25 activities and the helicopter activities are not expected to change.

All land traffic traveling to or from Cape Cod must use either the Bourne Bridge or Sagamore Bridge (Fig. 3.1). Essentially only two major highway routes (Routes 6 and 28) traverse the length of the Cape. While these and other two-lane highways and local roads are adequate for the level of use during the winter, they often are inadequate to handle summer traffic volumes. The Master Plan for the Camp Edwards Military Reservation discusses the problems associated with the traffic congestion that occurs in the summer (Massachusetts Army National Guard, 1984).

3.2.14 Coastal Zone Management

All of Cape Cod, including Otis ANGB, is within the Massachusetts Coastal Zone Management Program. The Coastal Zone Management Act of 1972 (CZMA) provides coastal states with the opportunity and funding to develop comprehensive management plans for their coastal regions. The primary focus of the CZMA is to allow the states to approve or deny federally funded transportation or sewage projects or actions related to dredging and navigation improvement projects. The Massachusetts Coastal Zone Management Program currently has 27 coastal zone management policies that serve as regulatory guidelines to protect and manage the coastal zone.

4 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION

4.1 DIRECT AND INDIRECT EFFECTS AND THEIR SIGNIFICANCE

4.1.1 Air Quality

Current air pollution emissions from ANG, ARNG, and Coast Guard aircraft and the emissions that would occur after the conversion were estimated with the Aircraft Engine Emissions Estimator (ACEE) Model (Seitchek, 1985). These estimates were used in the evaluation of air quality impacts of the conversion (Table 4.1). In the existing situation, there are 10 takeoff-landings and a combination of 30 touch-and-goes, low approaches, simulated flame outs, and missed approaches per day with the F-106. After the conversion, the F-106 operations would be replaced by 12 landing-takeoffs and a combination of 36 touch-and-goes, low approaches, simulated flame outs, and missed approaches by F-15 or F-16 aircraft (depending on the alternative selected). The current operations with all T-33 aircraft (one landing-takeoff and three touch-and-goes) would be terminated in FY 1987, and the current Coast Guard operations with HU-25 aircraft (five landing-takeoffs and ten touch-and-goes) would remain the same. The C-12 and U-8 would maintain their average of 0.5 landing-takeoff per day after the conversion. To calculate air pollutant emissions, it was assumed that pollutant emissions from transient aircraft using the Otis ANGB would be the same before and after the proposed conversion.

Table 4.1 shows that air pollutant emissions either would be reduced or remain the same after the conversion from F-106 to F-16 aircraft and would be reduced for all air pollutants except NO_x and SO_2 for the F-15. The increases in NO_x and SO_2 for the F-15 are due to the presence of two engines in that aircraft. Air quality would improve in the Otis ANGB environs for the F-16 alternative and for three of the five pollutants in the F-15 alternative. Airborne concentrations of NO_x and SO_2 for the F-15 alternative, although increased from the current F-106 scenario, would remain small, as described below.

The increased airborne concentrations of NO_x and SO_2 resulting from the F-15 conversion were estimated separately using the analysis procedure presented in the ACEE Model (Seitchek, 1985). A *worst-hour* of aircraft air pollutant emissions was identified during which each of five F-15 aircraft conducts one takeoff, three closed patterns, and no landings. (In reality, such operations take place over 1 1/2 h, so predicted concentrations were prorated to 1 h.) In the model calculations, all takeoffs were assumed to be made from Runway 14 to the southeast. Pollutant concentrations were calculated for the nearest point on the boundary of the Military Reservation (located on the extension of Runway 14 to the southeast) since it is the boundary point of highest probable airborne pollutant concentrations from the above worst-case F-15 flight scenario. This location is identified as point P in the following discussion. As recommended in the ACEE Model, conservative meteorological conditions were assumed (F stability, 1 m/s [4.8 mph] wind speed). The calculations indicated that maximum

TABLE 4.1 Comparisons of Annual Emissions of Pollutants by Aircraft before and after the Proposed Conversion[a]

Scenario	Emissions (metric tons/year)				
	CO	HC	NO_x	TSP	SO_2
Present situation					
Fixed wing					
F-106	85	54	23	2	5
T-33	11	1	-	-	-
C-12	2	2	1	-	-
HU-25	-	-	-	-	-
U-8	2	-	-	-	-
Transients	17	10	3	-	1
Helicopter					
UH-1H	4	2	6	-	-
OH-6A	4	-	1	-	-
HH-3F	44	10	22	1	1
Total	169	79	56	3	7
After conversion to F-16					
Fixed wing					
F-16	31	4	23	-	2
C-12	2	2	1	-	-
HU-25	-	-	-	-	-
U-8	2	-	-	-	-
Transients	17	10	3	-	1
Helicopter					
UH-1H	4	2	6	-	-
OH-6A	4	-	1	-	-
HH-3F	44	10	22	1	1
Total	104	28	56	1	4
After conversion to F-15					
Fixed wing					
F-15	54	6	44	1	7
C-12	2	2	1	-	-
HU-25	-	-	-	-	-
U-8	2	-	-	-	-
Transients	17	10	3	-	1

TABLE 4.1 (Cont'd)

Scenario	Emissions (metric tons/year) CO	HC	NO_x	TSP	SO_2
Helicopter					
UH-1H	4	2	6	-	-
OH-6A	4	-	1	-	-
HH-3F	44	10	22	1	1
Total	127	30	77	2	9

[a]Only aircraft sources were included in this inventory. Stationary and mobile sources on the ground (e.g., aviation ground equipment) on the Massachusetts Military Reservation also contribute to air pollution emissions, but such emissions (not listed here) would not be significantly changed by aircraft conversion activities.

airborne 24-h NO_x concentrations would be increased by 2.6 $\mu g/m^3$. Since annual NO_x concentrations would be less than maximum 24-h values, the total concentration at that boundary point would be 28 $\mu g/m^3$ (ambient) plus 2.6 $\mu g/m^2$ (increment due to F-15 conversion), or 31 $\mu g/m^3$. This total concentration would be well within the annual air quality standard of 100 $\mu g/m^3$.

Results of a similar analysis for SO_2 were as follows:

SO_2, 3-h average

New concentration at point P = ambient (164 $\mu g/m^3$) + F-15 flight increment (0.9 $\mu g/m^3$)

= 165 $\mu g/m^3$ < 1,300 $\mu g/m^3$ (air quality standard)

SO_2, 24-h average

New concentration at point P = ambient (109 $\mu g/m^3$) + F-15 flight increment (0.6 $\mu g/m^3$)

= 110 $\mu g/m^3$ < 365 $\mu g/m^3$ (air quality standard).

Thus, the increases in NO_x and SO_2 emissions caused by conversion to F-15 aircraft would add only very small increments to ambient concentration levels, and total concentrations would remain in compliance with National Ambient Air Quality Standards.

Various construction activities associated with the conversion would cause short-term emissions of fugitive dust, but the amount of dust released would be small. With implementation of appropriate control measures, the concentrations of total suspended particulates at the base boundary would be within limits of National Ambient Air Quality Standards. Control measures could include periodic watering or the use of chemical dust suppressants.

No significant cumulative air quality impacts would result from the combined pollutant emissions of Camp Edwards and Otis ANGB activities. Plumes of pollutants originating from ANG and ARNG activities rarely overlap at significant concentrations because of the spatial separation of the activities. Also, ambient concentrations of air pollutants (except for ozone) are considerably less than the limits set by the state standards. Current pollutant emissions from Camp Edwards are effectively accounted for in existing air quality data.

Exceedances of the ozone standard at the monitor located in Fairhaven (nine exceedances in 1984, for example) are due to regional pollution problems and are not directly due to emissions from the Massachusetts Military Reservation. Ozone is generally not released directly into the atmosphere from industrial or other sources, but is formed when reactive hydrocarbons (for example, vapors from gasoline, solvents, inks) and NO_x in the air chemically react with each other under exposure to sunlight.

Considering the comparatively large regional emissions of those pollutants, the NO_x and hydrocarbon emissions from aircraft engines are a small contributing factor to ozone formation.

4.1.2 Noise

Frequency of Flight Operations

The frequency of flight operations* would increase with the conversion from F-106 aircraft to F-16 or F-15 aircraft (Table 4.2). While the F-106 aircraft average 10 sorties‡ per day and the T-33 1 per day, the F-16 and F-15 would average 12 planned sorties per day. Two additional daily sorties of the F-16 or F-15 lead to 16 more daily operations for either of these aircraft.

Day-Night Average Sound Level

To evaluate the noise impacts of the proposed conversion, noise contours were produced (using the NOISEMAP methodology) for both the F-16 scenario (F-16, HU-25, transients, ground runup) and the F-15 scenario (F-15, HU-25, transients, ground runup). The contours are presented in Figs. 4.1 and 4.2 for the F-16 and F-15 scenarios, respectively. Superimposed on the contours in these figures are the contours for the current situation with F-106 aircraft.

Special F-15 and F-16 flights were conducted to obtain (for modeling purposes) data on the flight profiles (track distances, altitudes, power settings, and airspeeds) that would be used at Otis ANGB. Both aircraft flew the same ground tracks as that of the F-106, except for minor changes in turn radii specific to the capability of the F-15 or F-16. The F-15 was flown at Otis and the F-16 was flown at Atlantic City, New Jersey, ANGB. Video tape recordings of altitudes and air speeds were read at Otis; changes in power settings were orally entered on a tape recorder by the pilot.

Additional computer runs were prepared to better understand the controlling factors in these contours. Figure 4.3 presents contours for each of the component aircraft types that make up the F-16 and F-15 alternatives illustrated in Figs. 4.1 and 4.2.

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*A flight operation is a landing or takeoff; e.g., each touch-and-go equals two flight operations.

‡A sortie is an individual flight; it consists of a departure, an approach, and one or more closed patterns.

TABLE 4.2 Comparison of Average Daily Aircraft Operations at Otis ANGB for Current Situation and Two Conversion Alternatives

Aircraft Type	Departures	Arrivals	Closed Patterns	Takeoffs	Landings	Total Operations
Current Situation						
F-106	10	10	30	40	40	80
T-33	1	1	3	4	4	8
HU-25	4.85	4.85	10	14.85	14.85	29.7
HU-25 (nighttime)	0.05	0.05	0.1	0.15	0.15	0.3
C-12	0.5	0.5	0	0.5	0.5	1.0
U-8	0.5	0.5	0	0.5	0.5	1.0
	Fixed-wing operations subtotal					120.0
F-16 or F-15 Alternative						
F-16 or F-15	12	12	36	48	48	96
HU-25	4.85	4.85	10	14.85	14.85	29.7
HU-25 (nighttime)	0.05	0.05	0.1	0.15	0.15	0.3
C-12	0.5	0.5	0	0.5	0.5	1.0
U-8	0.5	0.5	0	0.5	0.5	1.0
	Fixed-wing operations subtotal					136.0
Helicopter (assigned)						
UH-1H	1.8	1.8	13.9[a]	15.7[a]	15.7[a]	31.4[a,b]
OH-6A	1.1	1.1	10.2[a]	11.3[a]	11.3[a]	22.6[a,b]
HH-3F	21.7	21.7	0	21.7	21.7	43.4
HH-3F (nighttime)	0.3	0.3	0	0.3	0.3	0.6
	Helicopter operations subtotal					98.0
Transient						
A-7	0.1754	0.1754	0	0.1754	0.1754	0.3508
A-10	0.0492	0.0492	0	0.0492	0.0492	0.0984
C-7	0.0440	0.0440	0	0.0440	0.0440	0.0880
C-9	0.0412	0.0412	0	0.0412	0.0412	0.0824
C-12	0.2520	0.2520	0	0.2520	0.2520	0.5040
C-21	0.0960	0.0960	0	0.0960	0.0960	0.1920
C-130	0.1726	0.1726	0	0.1726	0.1726	0.3452
KC-135	0.0248	0.0248	0	0.0248	0.0248	0.0496
F-4	0.1372	0.1372	0	0.1372	0.1372	0.2744
F-14	0.0164	0.0164	0	0.0164	0.0164	0.0328
P-3	1.0620	1.0620	0	1.0620	1.0620	2.1240

TABLE 4.2 (Cont'd)

Aircraft Type	Departures	Arrivals	Closed Patterns	Takeoffs	Landings	Total Operations
T-33	0.0574	0.0574	0	0.0574	0.0574	0.1148
T-37	0.2222	0.2222	0	0.2222	0.2222	0.4444
T-42	0.0796	0.0796	0	0.0796	0.0796	0.1592
		Transient operations subtotal				4.8600
Total Operations						
F-106 (existing situation)						223
F-16 Alternative						239
F-15 Alternative						239

[a]ARNG helicopter flight operations include hovering movements 3 to 5 ft AGL, which are included in the individual operations logged.

[b]Approximately 40% of these ARNG flight operations occur in the Camp Edwards R4101 Training Area.

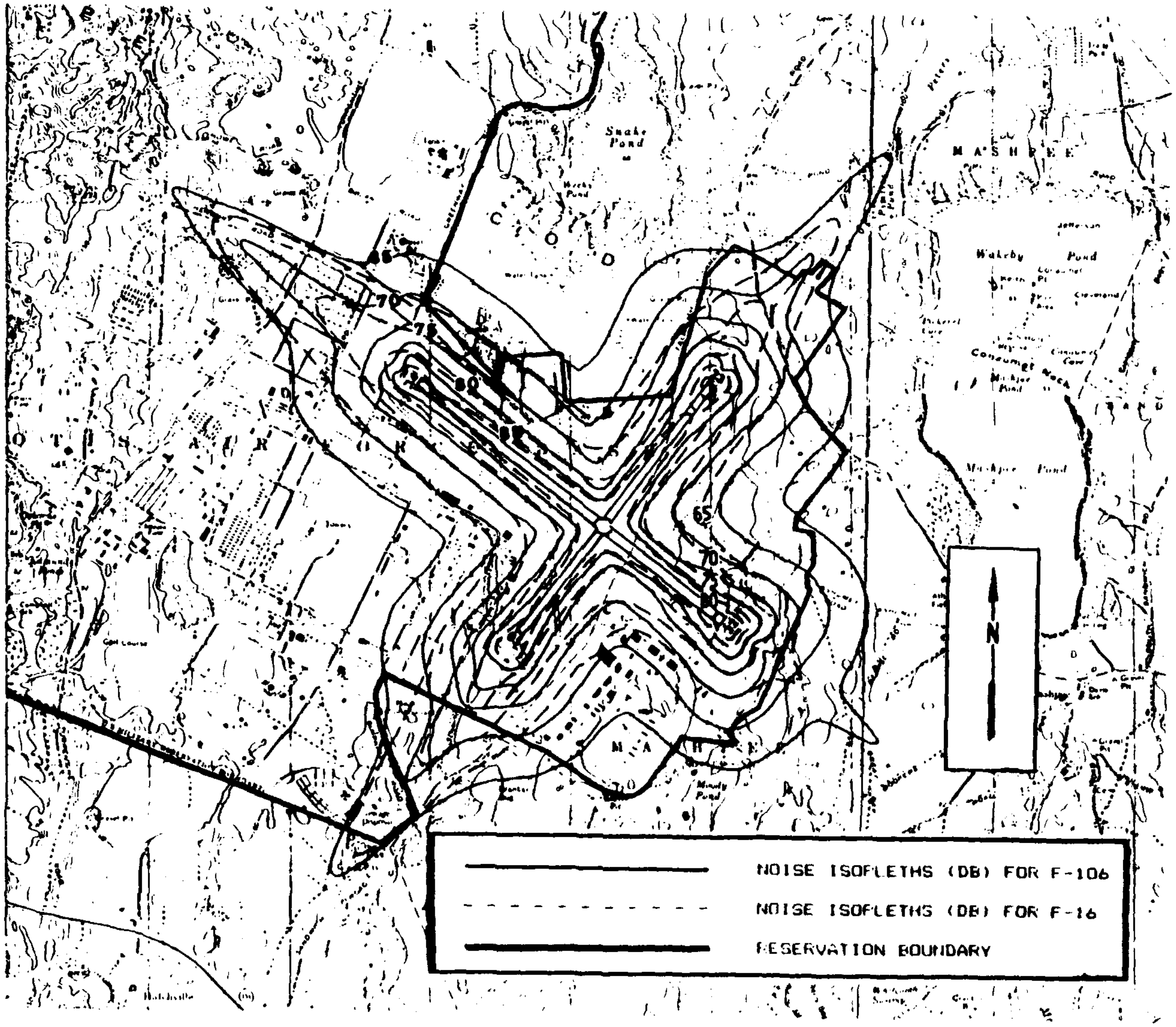


FIGURE 4.1 Comparison of Noise Contours for F-106 Scenario Flight Operations (current) and F-16 Scenario Flight Operations

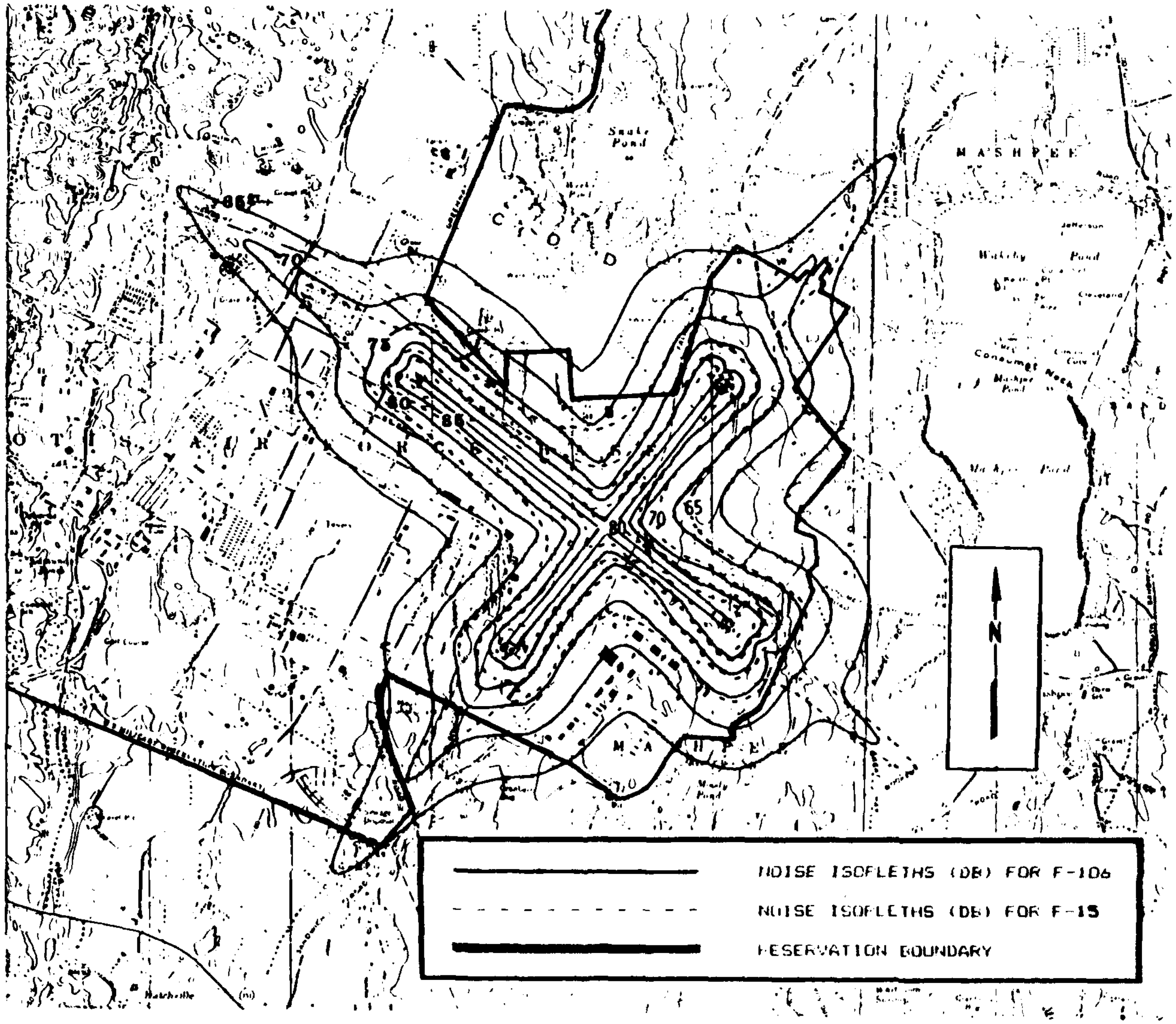
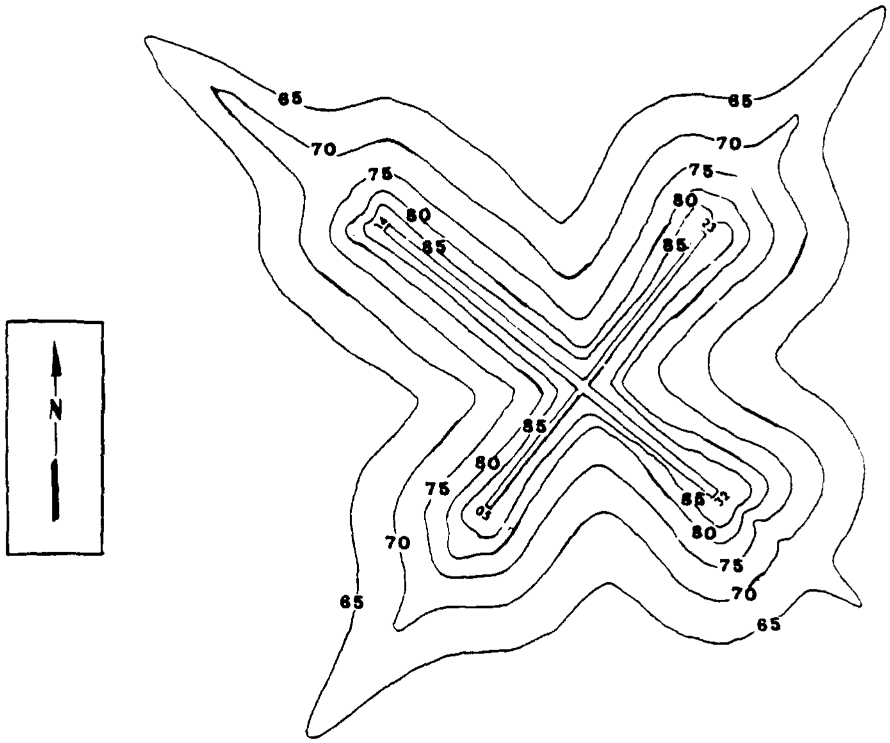
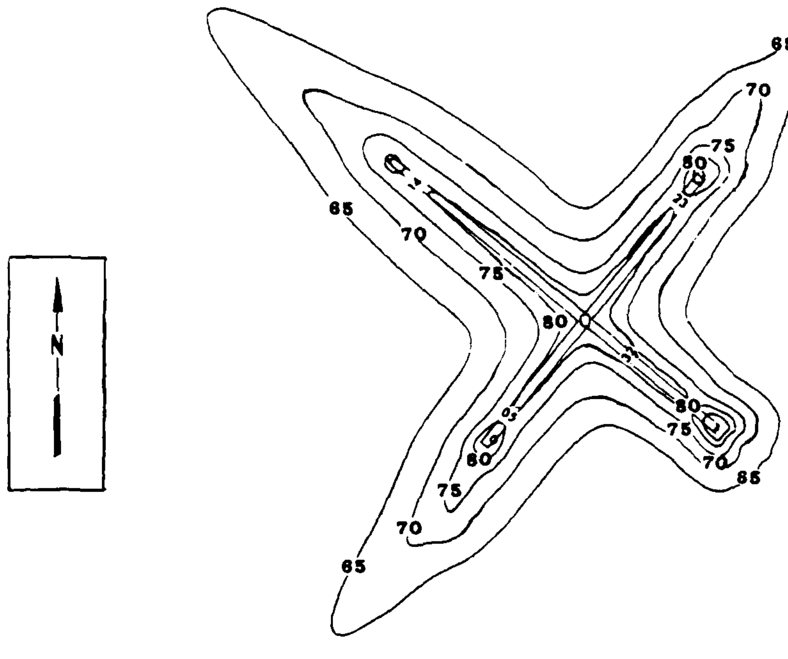


FIGURE 4.2 Comparison of Noise Contours for F-106 Scenario Flight Operations (current) and F-15 Scenario Flight Operations

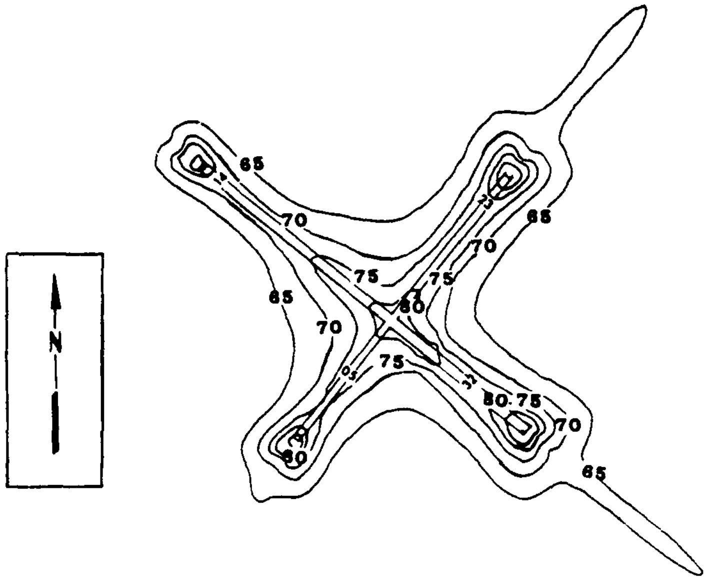


(a) F-106 alone

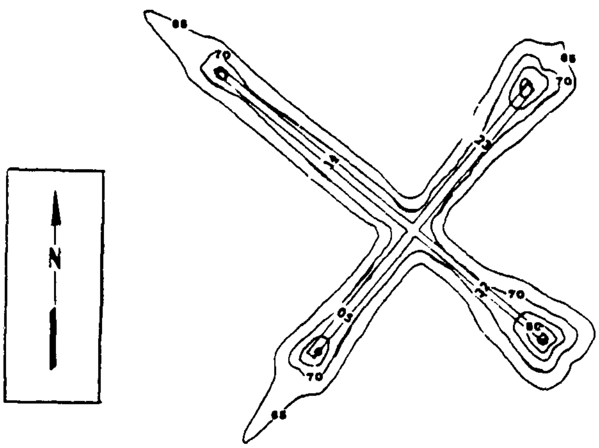


(b) F-16 alone

FIGURE 4.3 Comparison of Noise Contours (db) by Individual Aircraft Types

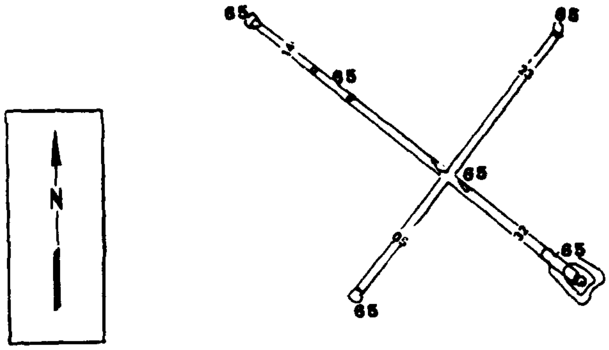


(c) F-15 alone

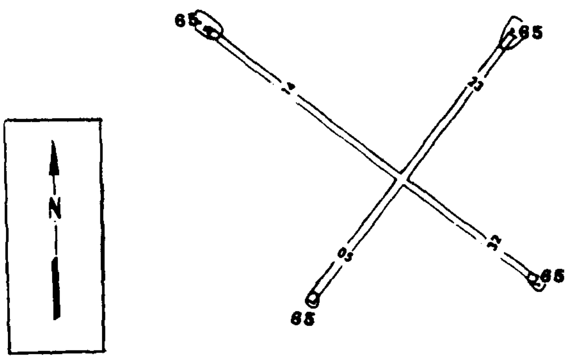


(d) Transients alone

FIGURE 4.3 (Continued)



(e) HU-25 alone



(f) T-33 alone

FIGURE 4.3 Continued

F-106 Alone -- The departure dominates the contours for the F-106 alone (Fig. 4.3). The larger lobes off the 14 and 05 ends of the runways are due to the 32 and 23 runway departures, respectively, along with the high frequency of utilization of those runways (32 runway, 50%; 23 runway, 30%). The smaller extent of the contours off the 32 and 23 ends are due to less frequent departures from the 14 and 05 runways (14 runway, 5%; 05 runway, 15%). For F-106 departures, the afterburner is turned off near the end of the runway (at an airspeed of 250 knots), at which time airspeed is increased to 310 knots and a constant-angle climb begins at this speed (310 knots, 95% power). This departure profile represents a noise abatement adjustment to the standard F-106 departure (see Sec. 3.2.2).

F-16 Alone -- The contours for the F-16 alone are smaller in all directions than those for the F-106 (Fig. 4.3). In this case also, the departure controls the contours and leads to expanded contours off the 14 and 05 ends of the runway (due to 32 and 23 departures). The F-16 has a slightly higher rate of climb than the F-106, and the power setting of the F-16 during the climb is constant at 90% with increasing airspeed. This greater altitude and lower power setting for the F-16 (as compared with the F-106) leads to smaller noise contours.

F-15 Alone -- A noise abatement departure profile was used in modeling the F-15 contours (Fig. 4.3). In this profile, takeoff is at 88% power (140 to 300 knots), with a reduction to 82% power at 1 nautical mile from the departure end of the runway. This 82% power is maintained (at a 300-knot airspeed) during a rapid rate of climb. Compared with the F-106, the F-15 has a significantly higher altitude in departure and lower power setting (95% vs. 82%). As a result, the F-15 noise contours are significantly smaller than those of the F-106. In fact, the noise-abatement departure profile for the F-15 proposed for Otis is so efficient at reducing noise that the F-15 approach noise is greater than the departure noise.

The long tails revealed by the contours at the 23 and 32 ends of the runways are caused by (1) the dominance of approach noise for the F-15 contours and (2) the greater frequency of utilization of the 23 and 32 ends of the runways for approaches. No tails (65 dB or greater contours) exist at the 05 and 14 runway ends because of the low frequencies of approaches at those runways. The bulges in the middle of the tails are due to closed patterns that cross the contours about the 23 and 32 runway ends. The bulge at the Runway 32 contour tail is due to Runway 05/23 closed patterns, and the 23 end contour tail is due to Runway 14/32 closed patterns.

Ground Tracks -- The ground tracks for the F-106 are plotted in Fig. 4.4. Similar plots for the F-16 and F-15 are nearly identical except for a few smaller turn radii.

Transients -- The transient aircraft contours in Fig. 4.3 are considerably smaller than any of the F-106, F-16, or F-15 contours. This is due to the relatively small number of transient aircraft operations. No closed patterns (only landing-takeoffs) occur with the transient aircraft; this results in the narrowness of the contours about the runways.

HU-25 and T-33 -- The noise contours in Fig. 4.3 for the HU-25 and T-33 aircraft are very small because of the low number of daily operations with these aircraft.

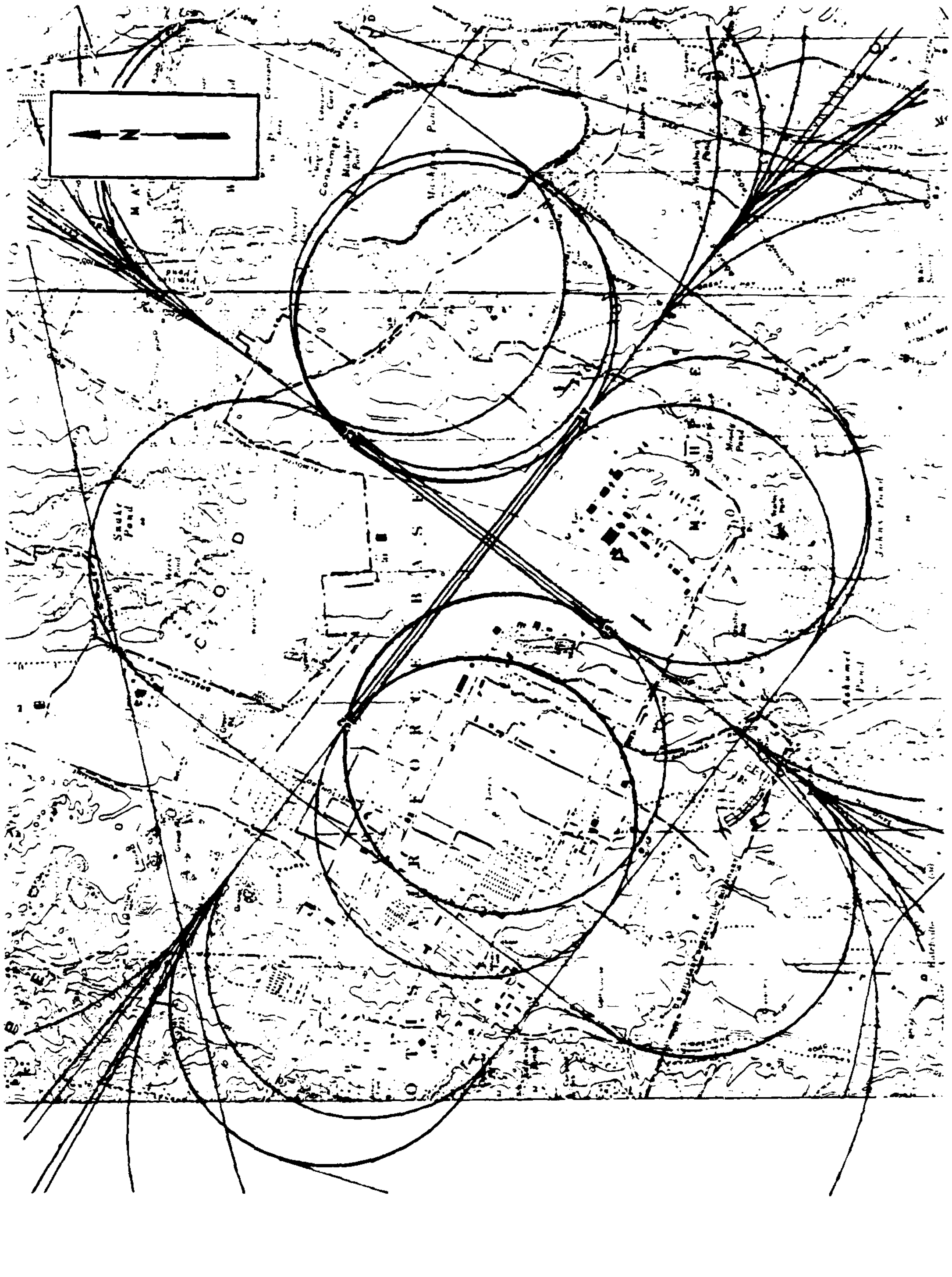


FIGURE 4.4 Ground Tracks due to F-106 Alone

Ground Runup -- Contours were calculated for F-106, F-16, and F-15 aircraft ground runup operations inside a hush house. However, in each case there were no contours at noise levels of 65 dB or greater, so no contours for ground runup could be plotted in Fig. 4.3.

F-16 Scenario -- Figure 4.1 shows that the existing F-106 contours (F-106 scenario) are significantly larger than those of the F-16 scenario. This condition is due to the relative sizes of the contours for the F-106 and F-16 aircraft themselves. The transients, HU-25, and T-33 aircraft have no significant effect on the contours.

F-15 Scenario -- Figure 4.2 shows that the existing F-106 contours (F-106 scenario) are significantly larger than those of the F-15 scenario. This again is due to the relative sizes of the contours for the F-106 and F-15 aircraft themselves rather than to contributions from any other aircraft using the base.

Noise contours were also prepared for the F-15 for a standard (rather than a noise-abatement) takeoff procedure. Under the standard procedure, takeoff power is at constant military power (93%). Altitudes are lower and power settings are higher (93% versus 82%) as compared with the noise-abatement F-15 departure profile described earlier. The noise contours from the standard F-15 takeoff pattern (not shown) were found to approximate the size of the F-106 noise contours. The comparison makes it clear that noise-abatement procedures can have significant effects on the size and extent of the noise contours.

Afterburner takeoffs, which are used for air defense scrambles, are not modeled due to their relatively infrequent occurrence.

Single-Event Analysis

Fourteen residential locations outside the military reservation, closest to ANG/ARNG noise sources, were selected for evaluation of worst-case noise impacts due to military activities (Table 4.3). Receptors 1-11 are identified in Appendix B (Table B.6 and Fig. B.7) in conjunction with the evaluation of combined noise impacts. Those 11 locations were supplemented with three additional locations, designated as Points A, B, and C. Point A is a residence in northern Mashpee on Great Neck Road near the centerline of Runway 14, Point B is a northern Mashpee residence on the centerline of Runway 05 between Pimlico and Peters Ponds, and Point C is in the residential community immediately southeast of Snake Pond.

The noisiest operations of the F-106 and each of the replacement aircraft were determined for each receptor. A departure or an approach was found to cause the maximum noise levels at each receptor location. In this analysis, the maximum noise level predicted at a particular receptor during this noisiest flyover characterizes the short-term impact of an individual event. Formation (two-craft) takeoffs and landings were assumed for the calculations (i.e., two F-106 or two replacement aircraft are landing or taking off at the same time). At Otis ANGB, 60% of F-106 departures are formation takeoffs and 40% are single-craft takeoffs. For both the F-15 and F-16

TABLE 4.3 Predictions of the Maximum A-Weighted Noise Levels (dB) at 14 Residential Locations for the Current Case (F-106) Compared with the F-16 and F-15 Alternatives

Receptor Location[a]	F-106		F-16		F-15	
	Departure	Approach	Departure	Approach	Departure	Approach
1	72	48	57	33	54	45
2	72	53	62	38	59	50
3	81	66	79	51	72	62
4	91	68	81	56	73	63
5	72	52	61	37	58	49
6	83	92	86	70	81	85
7	108	107	109	90	91	98
8	106	106	107	90	90	98
9	100	89	101	76	88	84
10	82	92	83	70	80	85
11	87	87	95	70	85	82
A	90	97	98	70	87	91
B	96	99	102	71	89	92
C	111	103	112	93	94	96

[a]Locations 1 through 11 are described in Appendix B, Table B.6, and are shown in Fig. B.7. Locations A, B, and C are described in Sec. 4.1.2 under the **Single-Event Analysis** subsection.

alternatives, it is expected that 75% of departures would involve two craft and 25% single craft. For all three types of aircraft, 25-30% of approaches are two-craft. Since two-craft departures and approaches are noisier (by 3 dB) than single-craft flights, only two-craft flights were considered in this single-event analysis (as well as in the analysis of Appendix B).

An existing computer code, OMEGA10 (Mohlman, 1983), designed to produce single-event aircraft noise data for specific engine power settings based on experimental data (Speakman et al., 1978a, 1978b) was used as a basis for a new computer code (developed at Argonne National Laboratory) to calculate the greatest maximum noise level at any receptor for each aircraft's flight path. For the Otis ANGB flight conditions, the calculations were made for points located every 100 ft along the flight path. Aircraft speed, power setting, and altitude at each point along the flight path were determined from the same flight profile data that were input directly to NOISEMAP. At each ground receptor location (A-C and 1-11), the maximum noise level was determined for each flight by first calculating the maximum level for every point along the flight path and then choosing the greatest value.

The results of these computations, as listed in Table 4.3, indicate that:

- For F-16 aircraft, the maximum A-weighted noise levels are lower than F-106 noise levels for some locations, but are slightly greater at other locations. These differences are small and were found to be a result of power setting and altitude differences between the F-106 and the F-16 for these particular locations.

- For F-16 aircraft, departure noise levels are greater than approach noise levels at all of these locations.

- For F-15 aircraft, the maximum A-weighted noise levels are lower than the levels for the F-106 aircraft at all of these locations, indicating reduced single-event noise impact.

In summary, conversion to F-16 aircraft would reduce maximum single-event noise levels at some locations and slightly increase maximum noise levels at others. Conversion to the F-15 aircraft would reduce maximum single-event noise levels at all of the 14 receptor locations considered.

Combined Impact of ARNG Gunfire and ANG Jet Aircraft Noise

The combined noise impacts (from ARNG, ANG, and Coast Guard activities) analyzed for the F-106 aircraft (Sec. 3 and Appendix B) also were analyzed for the two replacement aircraft. In the first evaluation method, the predictions of ARNG gunfire (L_{dn} based on C-weighting) and ANG/Coast Guard jet activity (L_{dn} based on A-weighting) were summed. The calculations for both replacement aircraft types indicated that the critical ANG and ARNG noise contours (62 dB for ARNG gunfire and 65 dB for jet noise) did not overlap off the military reservation.

The second method of evaluation involved determining which maximum sounds (from jets, helicopters, demolition, or gunfire) are dominant and could mask the other sounds using different ARNG, Coast Guard, and ANG activities and off-site locations. Results for the existing and two replacement aircraft are compared in detail in Appendix B.

On departures, the F-16 generally would cause a lower sound level in the community than does the F-106, as discussed previously in this section. Depending upon the off-site location involved, the conversion from F-106 to F-16 aircraft would lessen the combined noise levels. For example, the F-106 departure noise is much louder than a mortar shell burst, and the mortar shell burst is louder than the F-16 departure noise at the Sandwich/Shawme-Crowell State Forest area (receptor location 2). However, at the Sandwich/Pimlico Pond area (receptor location 7), the same mortar shell burst would be inaudible (masked) during the much louder F-106 and F-16 aircraft departures via Runway 05. In summary, depending upon location and scenario, the lower F-16 departure noise would provide a lessening of combined noise impacts. Conversion from F-106 to F-15 aircraft would reduce at all off-site locations noise levels due only to jet aircraft.

Near the air base, the ANG maximum jet noise predominates over the maximum Army gunfire noise (in terms of maximum loudness). At some locations near Camp Edwards, the Army impulsive noise predominates over the ANG jet noise, whether that noise is from an F-106 or replacement aircraft. In general, the relative noise impacts of either aircraft conversion alternative would be unaffected by simultaneous firing of Army weapons.

Noise Impacts on Land Use

Table 4.4 compares the number of off-site residents, occupied housing units, schools, hospitals, and acres of land within each of the noise isopleth zones for the three cases analyzed. Compared with the current situation (F-106 aircraft), fewer off-site residents would be exposed to noise under either conversion alternative. A maximum of 79 residents and 32 occupied housing units are exposed to L_{dn} noise levels in the 65-70 dB range under the baseline (F-106) conditions. For the F-15 alternative, 37 residents and 15 occupied housing units would be within the 65-70 dB contour zones; for the F-16 alternative, the numbers are 30 residents and 12 occupied housing units. It should be noted that a housing development is nearing completion in the City of Mashpee within less than 0.5 mi of the southeastern extension of Runway 14. This development is expected to increase by approximately 94 and 38, respectively, the number of people and occupied housing units exposed to L_{dn} noise levels in the 65-70 dB range. The land area exposed to various levels of noise is smallest for the F-15 alternative and greatest for the current conditions with F-106 aircraft. No off-site residents, occupied housing units, schools, or hospitals are exposed to L_{dn} noise levels above 70 dB for any of the alternatives.

Table 4.5 presents land-use compatibility guidelines based on the noise exposure levels depicted in Figs. 3.4, 4.1, and 4.2. Based on these noise levels, it is clear that both conversion alternatives would result in decreased noise levels in the local area. Although the replacement aircraft would fly more sorties per day (12) than the F-106 (10), the size of noise contours would be reduced because of the lower noise level of the replacement aircraft. Since either alternative aircraft would reduce noise levels in the vicinity of the base, the conversion is expected to have an overall positive impact on local land use.

4.1.3 Hazardous Materials

The environmental consequences discussed below for asbestos and hazardous materials (excluding hydrazine) would be the same for either replacement aircraft. Hydrazine would be present only if the F-16 is chosen as the replacement aircraft.

Asbestos

Asbestos is located in two buildings at Otis ANGB that would be affected by the proposed action. Asbestos located in Bldg. 165 and the alert facility will be removed under contract in accordance with all federal regulations designed to protect workers,

TABLE 4.4 Comparative Number of Off-Site Residents, Occupied Housing Units, Schools, Hospitals, and Acres of Land within L_{dn} Noise-Level Zones for the F-106, F-15, and F-16 Alternatives

L_{dn} Zone (dB)[a]	Number of Residents[b]	Number of Occupied Housing Units[b]	Number of Schools	Number of Hospitals	Acres of Land
Baseline Case (F-106)					
65-70	79	32	0	0	1,318
70-75	0	0	0	0	775
75-80	0	0	0	0	461
80-85	0	0	0	0	259
>85	0	0	0	0	326
F-15 Alternative					
65-70	37	15	0	0	684
70-75	0	0	0	0	283
75-80	0	0	0	0	214
80-85	0	0	0	0	77
>85	0	0	0	0	21
F-16 Alternative					
65-70	30	12	0	0	871
70-75	0	0	0	0	493
75-80	0	0	0	0	271
80-85	0	0	0	0	184
>85	0	0	0	0	16

[a]Values represent the contour lines shown in Figs. 3.4, 4.1, and 4.2. For each alternative, the noise contour calculations included all aircraft that would be using the base.

[b]These figures represent population and occupied housing units that existed as of April 10, 1987. A housing development was being built in the city of Mashpee within less than 0.5 mi of the southeastern portion of the base (near the intersection of Bearse Road and Great Hay Road). Although no one lived in the development at the time, 28 houses were nearing completion, and an estimated 10 additional homes were expected to be built soon. Most of these homes would be within the 65-70 dB zone for the F-106 and F-15 alternatives. This would add an estimated 38 occupied housing units and 94 people to the values given in these columns for the F-106 and F-15 alternatives. The 65-70 dB noise contour would not reach into this housing development for the F-16 alternative, and therefore the residents and occupied housing units would not be exposed to L_{dn} levels above 65 dB.

TABLE 4.5 Land Use Compatibility Guidelines[a]

Land Use Category	Day/Night Average Sound Levels (dB) >85	80-85	75-80	70-75	65-70
Residential	I	I	I	30[b]	25[b]
Industrial/Manufacturing	I	C[c]	C[d]	C[e]	C
Transportation, Communication, and Utilities	C	C	C	C	C
Commercial Retail Trade	I	I	30	35	C
Personal and Business Services	I	I	30	25	C
Public and Quasi-Public Services	I	I	I	30	25
Outdoor Recreation	I	I	I	C[f,g]	C
Resources Production, Open Space	C	C[h]	C[h]	C	C

[a]Alphanumeric entries have the following meanings.

I - Incompatible: The land use and related structures are not compatible and should be prohibited.

C - Compatible: The land use and related structures are compatible without restriction and should be considered.

35, 30, or 25: The land use is generally compatible; however, a Noise Level Reduction (NLR) of 35, 30 or 25 must be incorporated into the design and construction of the structure.

35^x, 30^x, or 25^x: The land use is generally compatible with NLR; however, such NLR does not necessarily solve noise difficulties and additional evaluation is warranted.

[b]Although local conditions may require residential uses in a compatible use district (CUD), this use is strongly discouraged in L_{dn} 70-75 and discouraged in L_{dn} 65-70. The absence of viable development alternatives should be determined and it should be shown that a demonstrated community need for residential use would not be met if development were prohibited in these CUDs.

[c]An NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, where office areas are located, or where the normal noise level is low.

[d]An NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, where office areas are located, or where the normal noise level is low.

[e]An NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, where office areas are located, or where the normal noise level is low.

[f]Facilities must be low intensity.

[g]An NLR of 25 must be incorporated into buildings for this use.

[h]Residential structures not permitted.

the public, and the environment. These considerations indicate that impacts of asbestos removal would not be an important problem.

Other Hazardous Materials

Other hazardous materials (as listed in Sec. 3.2.4) are currently managed on the Otis ANGB in accordance with relevant state, federal, and ANG regulations. The types of wastes and the procedures for managing them would not differ after the conversion. The volumes of these wastes are expected to decrease in the future because of a policy to minimize wastes. Thus, it is expected that aircraft conversion would have no major effects on potential impacts from hazardous waste management.

Hydrazine — F-16 Alternative Only

Hydrazine, a clear, oily liquid that evaporates at a rate similar to that of water at any given temperature, would be used in the F-16 aircraft as the source of emergency power for instruments and controls during temporary engine failure. Hydrazine is rated as a hazardous material because it is flammable and produces toxic effects in humans and lower organisms through ingestion, inhalation, or skin absorption. Two chemical properties of hydrazine are important to its use and handling at an air base. One is reaction on contact with a catalyst to yield large volumes of gases that can be used to provide hydraulic power or, on expansion through a turbine, electric power. This property is applied in the emergency power unit of the F-16 aircraft. The other important chemical property is reaction with hypochlorites, such as household bleach or a 65% calcium hypochlorite substance (referred to as high-test hypochlorite, or HTH) to yield innocuous compounds: nitrogen, water, and sodium chloride (in the case of bleach) or calcium chloride (in the case of HTH). This property is applied in neutralization of spilled hydrazine.

Hydrazine fuel would be delivered to the base as a mixture of 70% hydrazine and 30% water). Because of its 70% concentration, the fuel is referred to as H-70. The H-70 would be transported in 55-gal stainless steel drums (each packed in a styrofoam cask) by commercial carrier accompanied by a security escort. The total inventory at Otis ANGB would be two 55-gal drums of H-70 and the 6.8 gal present in each aircraft. Because H-70 would be used only during infrequent engine failure, its consumption rate would be variable but relatively small. The average rate might be about 150 gal per year for 18 F-16 aircraft. The H-70 would be carried by an F-16 aircraft in a 6.8-gal tank attached to or removed from the aircraft on the flight line. Tanks partly emptied by fuel use would be removed from the aircraft and transported to the hydrazine facility, a ventilated building with an area of about 810 ft^2.

Operations carried out in the hydrazine facility would include storage of the H-70 inventory, filling and emptying of tanks, and collection of any drippings from those operations. Normally no waste H-70 would be generated; the residual in any tank would be collected for recycling. Any fuel shown to be unusable by tests would be removed from the base by a U.S. Department of Defense (DOD) agency. The sink and drains in the H-70 facility would conduct any spilled liquid to a drain tank containing bleach to

neutralize the hydrazine. The contents of the drain tank -- a dilute, aqueous solution of bleach and the salts formed by neutralization -- would also be transferred to another agency for disposal.

The potential impacts of normal operation with hydrazine would involve exposure of technicians rather than of the environment. Permissible exposure limits, recommended procedures and equipment for meeting the limits, and proper handling and spill response procedures are given in AFOSH Standard 161-13 (Department of the Air Force, 1979). In normal operations on the flight line, the equipment and procedures used in changing tanks on aircraft would negate the inhalation hazard to pilots and technicians. In normal operations in the hydrazine facility, impacts would be minimized by use of forced-air ventilation, protective clothing, air packs, and a special system for refilling tanks. The system would be closed, and the tanks would be refilled above a sink in which drippings would be caught and neutralized. Concentrations of hydrazine in the air would be monitored in indoor areas, hangars, and the hydrazine facility, as necessary.

Control of the potential impacts from both normal operations and mishaps involving hydrazine would be based on procedures and equipment specified in Air Force regulations and also on state regulations for handling of hazardous wastes. The effective use of these procedures and equipment would be based on training of personnel in specific assignments for normal operations and mishaps.

Operations with hydrazine carried out in accordance with these plans would result in minor impacts on base personnel and on the air quality and groundwater of the base and surrounding communities.

4.1.4 Herbicides and Pesticides

The routine application of herbicides and pesticides in accordance with appropriate state and federal regulations is described in Sec. 3.2.5. The rate of application and the procedures used, and thus the potential impacts, would not be changed by conversion to either replacement aircraft.

4.1.5 Water Supply and Treatment

The J well would continue to supply adequate amounts of water for the Otis ANGB regardless of the replacement aircraft selected. Since the sewage treatment facility is only operating at 30-60% of the permitted capacity (due to sand filter bed limitations and permit restrictions imposed by the Massachusetts Department of Environmental Quality and Engineering), the conversion would not affect the sewage treatment capability of Otis ANGB or the remainder of the Massachusetts Military Reservation. It is also anticipated that water-using activities (e.g., washing of aircraft) for the replacement aircraft would be nearly identical to those for the current F-106 aircraft. Since nothing would be added to the facility that would change current usage, no increased impacts to water supply or treatment are anticipated from the conversion. The potential for impacts to water quality from use of hydrazine were discussed in Sec. 4.1.3.

4.1.6 Land and Soil Quality

The only new construction projects related to the conversion that would result in excavation work are the munitions maintenance and storage facility, the composite squadron operation facility, and the alternate fuel facility. All of these new construction projects would occur in areas on the base that are surrounded by existing buildings and structures. Thus, past construction activities in these locations have already altered the original soil conditions and drainage patterns. Site grading during the early phases of construction may result in a temporary increase in soil erosion rates. However, soil stabilization (e.g., seeding) after this construction phase would limit erosion potential. Therefore, no important changes in land and soil conditions would be associated with the aircraft conversion.

4.1.7 Vegetation and Wildlife Resources

The conversion would have no important changes on the vegetation and wildlife within the Massachusetts Military Reservation. Total noise levels from the replacement aircraft operations would be reduced from those now occurring with F-106 operations, and the noise impacts on wildlife would be reduced. Construction of the munitions storage and maintenance facility would occur next to the current fenced munitions storage area on land that is owned by the government. The area is already cleared and regularly mowed to maintain an open perimeter area. However, the granting of restrictive easements for 51 acres next to the munitions maintenance and storage facility and the alert facility would result in the maintenance of valuable habitat for natural vegetation and wildlife. Thus, minimal disturbances and some enhancements are expected for either replacement aircraft.

4.1.8 Threatened and Endangered Species

There are no known federally threatened or endangered species at Otis ANGB. The state-listed upland sandpiper, northern harrier, and grasshopper sparrow populations on the base have not been sighted in areas that would be affected by any activities associated with the conversion (see Figs. 3.5 through 3.7). In addition, the reduced noise of the replacement aircraft at take off should reduce noise stress for these three grassland bird populations. This reduction in noise levels would constitute an environmental enhancement for these species, especially during the mating and nesting period.

4.1.9 Socioeconomic Factors

Construction and operational activities associated with the conversion to either replacement aircraft are not expected to affect population levels, community services, or housing in the Upper Cape area.

4.1.10 Cultural Resources

Construction and operational activities for either replacement aircraft would not impact any known cultural, historical, or archaeological sites (Talmage, 1986). However, undiscovered sites might be uncovered, damaged, or destroyed during some excavation activities. Construction impacts to cultural resources can be avoided or reduced by adhering to the mitigative measures discussed in Sec. 4.4.

4.1.11 Land Use

Construction activities are not expected to produce major changes in current land use surrounding the Otis ANGB. The largest change in land use associated with the aircraft conversion would be the need for an additional restrictive easement as a safety zone adjacent to the munitions storage and maintenance facility area. The Town of Mashpee has placed restricted access on the 51 acres of land adjacent to the munitions maintenance and storage area and the alert facility. This land has been permanently set aside as a wildlife management area, which will satisfy requirements for the additional safety zone. The existing and proposed safety easements are shown in Fig. 4.5. Although permanent dwellings would be prohibited within the easements, agriculture, grazing, transportation, and utility rights-of-way would be allowed, subject to ANG approval. In accordance with the stipulations that the land owned by the Town of Mashpee be used for passive recreation needs, dispersed recreational activities (e.g., hiking, picnicking, hunting) would be allowed within the restricted easement area, thereby minimizing any conflicting land use. This change would occur regardless of alternative replacement aircraft selected.

4.1.12 Air and Land Traffic

The conversion action would slightly change air traffic operations. Currently, ANG flight activities consist of about 11 daily sorties (10 for F-106 and 1 for T-33). After conversion, operations would increase to about 12 sorties per day regardless of the replacement aircraft selected. Training airspace utilization would remain the same as that for the current F-106 operations (Sec. 3.2.3).

Direct land traffic impacts from the transport of workers and materials to and from Otis ANGB would be minimal with the alternative aircraft and would be limited to construction-related traffic during the construction period and to the new employees. A cumulative impact on local traffic levels would result because of additional construction traffic generated during the demolition, rehabilitation, and construction activities that would be performed by both the ARNG and ANG during the aircraft conversion process. Minor delays of local and tourist traffic might occur on the routes used by construction-related autos and trucks.

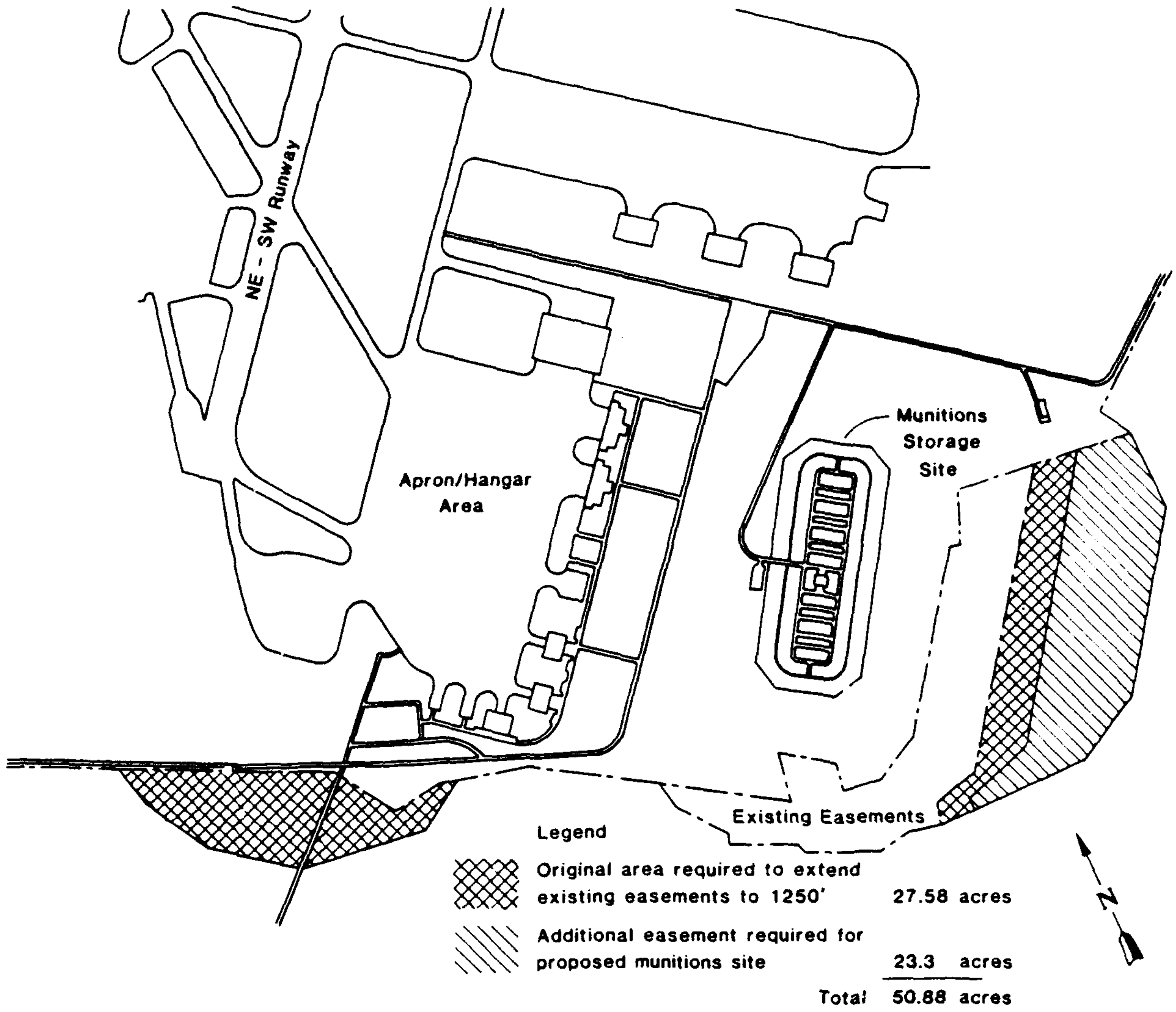


FIGURE 4.5 Locations of Existing and Proposed Safety Easements at Otis ANGB

4.1.13 Coastal Zone Management

The proposed conversion to either replacement aircraft would be a federal action taking place in a CZM area, but the conversion activities would not require a federal permit or license. Furthermore, the conversion activities would not affect navigable waters or coastal wetlands and waters. Thus, the proposed action would not require a federal consistency review.

4.2 RELATIONSHIP OF PROPOSED ACTION TO OBJECTIVES OF LAND USE PLANS, POLICIES, AND CONTROLS

The proposed aircraft conversion would not adversely affect the overall objectives of current land use plans, policies, and controls of the four towns adjacent to

Otis ANGB. However, the ANG and the Town of Mashpee need to finalize an easement agreement concerning the acreage and types of activities to be allowed on lands required for a restrictive easement as a safety zone adjacent to the Otis ANGB munitions maintenance and storage area.

4.3 ADVERSE ENVIRONMENTAL EFFECTS THAT CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

The proposed conversion would result in no adverse environmental effects that could not be avoided.

4.4 MITIGATIVE MEASURES

If historic or archeological artifacts are discovered during excavation activities, the Massachusetts State Historic Preservation Officer (SHPO) must be notified immediately. A determination would be made by the SHPO as to the appropriate mitigative measures to be followed. This would apply to either conversion alternative.

If the F-16 were selected as the replacement aircraft, certain mitigative measures would be required relative to the use and storage of hydrazine, which is not used for the F-106 or F-15 aircraft. Accidental ignition of hydrazine would be prevented by electrical grounding of equipment and by storing the liquid in steel containers. For technicians, such impacts as eye irritation and toxic effects resulting from inhalation and skin absorption would be prevented by the use of rubber gloves, protective clothing, and face shields. Safety showers and eye-wash fountains would also be available.

Because concentrations of hydrazine in the air within less than 50 ft from spills could exceed guidelines, a spill-response team of trained personnel would be prepared to neutralize spilled H-70 quickly (Department of the Air Force, 1979). The team would carry out spill countermeasures developed by the Air Force and adapted for use at the Otis ANGB as described in the Hazardous Materials Management Plan for the base (Massachusetts Air National Guard, 1985). Equipment available to the team would include protective clothing, air packs, neutralization chemicals, and equipment for retrieval and containment of spilled liquids. The procedures for treating spills of H-70 would involve surrounding the spill with an absorbent dam of rags and diluting with water. The diluted liquid would then be mopped up and placed into containers to be removed later by the Defense Reutilization and Marketing Office. Household bleach would be used to neutralize any hydrazine remaining on the pavement; any excess chlorine from the bleach could be destroyed, if necessary, by sodium thiosulfate solution. Massachusetts regulations on treatment of hazardous wastes would be observed in management of spilled hydrazine.

4.5 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

Operational activities associated with the proposed aircraft conversion would be consistent with the present and historical role of the ANG activities at Otis ANGB. The locations that would be altered by construction activities already are surrounded by buildings and have been extensively altered over the past 50 years. Thus, the long-term productivity of the site (in terms of natural vegetation and wildlife populations) has already been compromised by past activities.

4.6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Capital, energy, materials, and labor would be committed to the construction and rehabilitation of aircraft support facilities.

5 REFERENCES*

Camp Dresser and McKee, Inc., *Final Report: Otis Wastewater Treatment Evaluation*, Boston (Sept. 20, 1985).

Cape Cod Planning and Economic Development Commission, *The Economy of Cape Cod—An Overview of Considerations*, Barnstable, Mass. (1982).

Cape Cod Planning and Economic Development Commission, *Cape Cod Traffic Counting Program Report*, Barnstable, Mass. (1985).

Cape Cod Planning and Economic Development Commission, *Economic Profiles—Bourne, Falmonth, Mashpee and Sandwich*, Barnstable, Mass. (Undated-a).

Cape Cod Planning and Economic Development Commission, *Barnstable County Employment and Payrolls 1984*, Barnstable, Mass. (Undated-b).

Cape Cod Planning and Economic Development Commission, *Upper Cape Population and Housing by Town 1970-80*, Barnstable, Mass. (Undated-c).

Cape Cod Planning and Economic Development Commission, *Cape Cod Land Use 1951-1971-1980*, Barnstable, Mass. (Undated-d).

Cape Cod Planning and Economic Development Commission, *Barnstable County Population, by Town, 1980-2000*, Barnstable, Mass. (Undated-e).

Council on Environmental Quality, *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act*, 40 Code of Federal Regulations 1500-1508, Washington, D.C. (1978).

Department of the Air Force, *Occupational Health Exposure to Hydrazine*, AFOSH Standard 161-13, Headquarters U.S. Air Force, Washington, D.C. (Dec. 26, 1979).

Department of the Army, *Environmental Quality, Environmental Protection and Enhancement*, U.S. Army Regulation No. 200-1, Chapter 7, Washington, D.C. (June 15, 1982).

Dugan, R., Environmental Coordinator, Massachusetts Air National Guard, Otis Air National Guard Base, Mass., personal communication (April 1986).

E.C. Jordan, Inc., *Water Supply Study at Massachusetts Military Reservation, Cape Cod, Massachusetts, Final Report: Task 3-1*, Oak Ridge National Laboratory, Oak Ridge, Tenn. (1987).

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*In this reference list, the term "personal communication" is used to indicate either a telephone conversation or a face-to-face conversation.

Flaherty, J., M. Naughton, and G. Stimus, Massachusetts Air National Guard, Otis Air National Guard Base, Mass., personal communications (April 1986).

Fudala, F.T., et al., *Management Plan—Johns Pond Park*, Town of Mashpee, Mass. (1985).

Guswa, J.H., and D.R. LeBlanc, *Digit Models of Ground-Water Flow in the Cape Cod Aquifer System, Massachusetts*, U.S. Geological Survey Water-Supply Paper 2209, Reston, Va. (1985).

Kerfoot, W.B., and B.T. Ketchum, *Cape Cod Waste Water Renovation and Retrieval System, a Study of Water Treatment and Conservation*, Woods Hole Oceanographic Institution Technical Report WHOI-74-13, Woods Hole, Mass. (1974).

LeBlanc, D.R., *Sewage Plume in a Sand and Gravel Aquifer, Cape Cod, Massachusetts*, U.S. Geological Survey Water-Supply Paper 2218, Reston, Va. (1984).

Massachusetts Air National Guard, *Hazardous Materials Management Plan: Contingency Plan - Spill Prevention Control and Countermeasures*, 102nd Civil Engineering Flight, Otis Air National Guard Base, Mass. (Feb. 1985).

Massachusetts Army National Guard, *Master Plan — Camp Edwards Military Reservation, Bourne Massachusetts*, Directorate of Facilities Engineering, Boston (1984, as revised).

Massachusetts Army National Guard, *Environmental Assessment, Camp Edwards Military Reservation, Bourne, Massachusetts*, Directorate of Facilities Engineering, Boston (1985).

Metcalf, H.L., *Memorandum for AFPREV, Use of C-weighted Noise Measure*, Department of Defense, Washington, D.C. (June 29, 1977).

Mohlman, H.T., *Computer Programs for Producing Single-Event Aircraft Noise Data for Specific Engine Power and Meteorological Conditions for Use with USAF Community Noise Mode (NOISEMAP)*, Aerospace Medical Research Laboratory Report AMRL-TR-83-020, Wright-Patterson Air Force Base, Ohio (April 1983).

Otis Air National Guard Base, *Air Installation Compatible Use Zone (AICUZ)*, Otis Air National Guard base, Mass. (Sept. 1980).

Schultz, T.J., *Community Noise Rating* (Second Edition), Applied Science Publishers, New York (1982).

Seitchek, G.D., *Aircraft Engine Emissions Estimator*, Engineering and Services Laboratory Report ESL-TR-85-14, Air Force Engineering and Services Center, Tyndall Air Force Base, Fla. (Nov. 1985).

Speakman, J.D., R.G. Powell, and R.A. Lee, *Community Noise Exposure Resulting from Aircraft Operations: Volume 3. Acoustic Data on Military Aircraft: Air Force Attack/Fighter Aircraft*, U.S. Air Force Aerospace Medical Research Laboratory Report AMRL-TR-73-110(3), Wright-Patterson Air Force Base, Ohio (1978a).

Speakman, J.D., R.G. Powell, and R.A. Lee, *Community Noise Exposure Resulting from Aircraft Operations: Volume 4. Acoustic Data on Air Force Trainer/Fighter Aircraft*, U.S. Air Force Aerospace Medical Research Laboratory Report AMRL-TR-73-110(4), Wright-Patterson Air Force Base, Ohio (1978b).

Talmage, V.A., Massachusetts State Historic Preservation Office, Boston, personal communication (Sept. 3, 1986).

U.S. Census Bureau, *County and City Data Book*, U.S. Government Printing Office, Washington, D.C. (1983).

U.S. Environmental Protection Agency, *National Interim Primary Drinking Water Regulations: Maximum Contaminant Levels*, 40 Code of Federal Regulations 141.11, Federal Register, 50(219):46880-47025, Washington, D.C. (Nov. 13, 1983).

White, R.P, and S.M. Melvin, *Rare Grassland Birds and Management Recommendations for Camp Edwards/Otis Air National Guard Base*, Massachusetts Division of Fisheries and Wildlife, Natural Heritage Program, Boston (1985).

Whittaker, R.H., *Communities and Ecosystems*, Macmillan Publishing Co., New York (1975).

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APPENDIX A:

L_{dn} METHODOLOGY

A.1 NOISE ENVIRONMENT DESCRIPTOR

The day-night average sound level (L_{dn}) system of describing the noise environment was used to produce the noise contours presented in this assessment. Efforts to provide a national uniform standard for noise assessment have resulted in adoption by the U.S. Environmental Protection Agency (U.S. EPA) of L_{dn} as the standard measure of noise for this procedure. Air Force studies have established the accuracy of their NOISEMAP computer model, in terms of L_{dn} methodology, to be 1 to 2 dB. It is used by numerous federal agencies, including the Department of Defense, Department of Housing and Urban Development, and the Federal Aviation Administration.

The L_{dn} descriptor is a method of assessing the amount of exposure to aircraft noise and predicting the percentage of residents in a well-populated community that are "highly annoyed (% HA)" by the various levels of exposure (Committee on Hearing, Bioacoustics, and Mechanics, 1977; Schultz, 1978). The L_{dn} values (in dB) used for planning purposes and for which contours are presented in this assessment are 65, 70, 75, 80, and 85. Land use guidelines are based on the compatibility of various land uses with these exposure levels (U.S. Department of Defense, 1964).

It is generally recognized that a noise environment descriptor should consider, in addition to the annoyance of a single event, the effect of repetition of such events and the time of day in which these events occur. L_{dn} computation begins with a single-event descriptor and adds corrections for the number of events and the time of day. Since the primary noise impact relates to residential areas, nighttime events are considered more annoying than daytime events and are weighted 10 dB accordingly. The L_{dn} values are computed by first logarithmically summing the single-event energy descriptors for all of the flight operations in a typical 24-h day (after adding the 10 dB penalty to all nighttime operation levels); then the level is averaged for a 24-h period (Acoustical Society of America, 1980).

As part of an extensive data-collection process, detailed information is gathered on the flight tracks flown by each type of aircraft assigned to the base and the number and time of day of flights on each of these tracks during a typical day. This information is used in conjunction with the single-event noise descriptor to produce L_{dn} values. These values are combined on an energy summation basis to provide single L_{dn} values for the mix of aircraft operations at the base. Equal value points are connected to form the contour lines.

A.2 NOISE EVENT DESCRIPTOR

The single-event noise energy descriptor used in the L_{dn} system is the sound exposure level (SEL). The SEL measure is an integration of the A-weighted noise level over the period of a single event, such as an aircraft flyover, in dB, with a reference

duration of 1 second. Frequency, magnitude, and duration vary according to aircraft type, engine type, and power setting. Therefore, individual aircraft noise data are collected for various types of aircraft/engines at different power settings and phases of flight. SEL versus slant range values are derived from noise measurements made according to a source noise data acquisition plan developed by Bolt, Beranek and Newman, Inc. in conjunction with the Air Force Aerospace Medical Research Laboratory (AMRL) and carried out by AMRL (Bishop and Galloway, 1975). These standard-day, sea-level values form the basis for the individual-event noise descriptors at any location and are adjusted to the location by applying appropriate corrections for temperature, humidity, altitude, and variations from standard profiles and power settings.

Ground-to-ground sound propagation characteristics are used for ground runup activities. Air-to-ground propagation characteristics are used whenever the aircraft is airborne and the line-of-sight from observer to aircraft is 7 degrees or greater above horizontal; if the line-of-sight is 4 degrees or less, ground-to-ground propagation characteristics are used. Between these angles, propagation characteristics are interpolated (Speakman et al., 1977).

In addition to assessing aircraft flight operations, the L_{dn} system also incorporates aircraft and engine ground runup or tests resulting from engine/aircraft maintenance checks on the ground. Sounds such as aircraft/engine ground runup noise are essentially constant in level during each test run at a given power setting. Data on the orientation of the noise source, type of aircraft or engine, number of test runs on a typical day, the power settings used and their duration, and use of suppression devices are collected for each ground runup or test position. This information is processed along with *mean sound pressure level* (average-energy level) data to yield equivalent time-integrated sound exposure levels, which are added (on an energy summation basis) to the noise generated by flight operations to produce L_{dn} contours reflecting the overall noise environment with respect to air and ground operations by aircraft.

A.3 NOISE CONTOUR PRODUCTION

Data describing flight tracks, flight profiles, power settings, flight paths and profile utilization, and ground runup information by type aircraft/engine are assembled and processed for input into a central computer. L_{dn} contours are generated by the computer using the airfield-supplied operational data and the standard source noise data corrected to local conditions. The computer system plots these contours, which are provided in the text.

A.4 REFERENCES

Acoustical Society of America, *American National Standard Sound Level Description for Determination of Compatible Land Use*, ANSI S3.23-1980 (R1986), New York (1980).

Bishop, D.E., and W.J. Galloway, *Community Noise Exposure Resulting from Aircraft Operations: Acquisition and Analysis of Aircraft Noise and Performance Data*, U.S. Air Force Aerospace Medical Research Laboratory Report AMRL-TR-73-107, Wright-Patterson Air Force Base, Ohio (Aug. 1975).

Committee on Hearing, Bioacoustics, and Mechanics, Working Group 69, *Guidelines for Preparing Environmental Impact Statements on Noise*, National Research Council, National Academy of Sciences, Washington, D.C. (1977).

Schultz, T.J., *Synthesis of Social Surveys on Noise Annoyance*, J. of the Acoustical Society of America, 64:377-405 (1978).

Speakman, J.D., R.G. Powell, and J.N. Cole, *Community Noise Exposure Resulting from Aircraft Operations: Volume 1. Acoustic Data on Military Aircraft*, U.S. Air Force Aerospace Medical Research Laboratory Report AMRL-TR-73-110(1), Wright-Patterson Air Force Base, Ohio (Nov. 1977).

U.S. Department of Defense, *Land Use Planning with Respect to Aircraft Noise*, Report AFM 86-5, TM 5-365, NAVDOCKS P-98, Washington, D.C. (Oct. 1, 1964).

APPENDIX B:

MATHEMATICAL MODELING OF THE COMBINED IMPACTS OF NOISE FROM ARMY NATIONAL GUARD, AIR NATIONAL GUARD, AND COAST GUARD ACTIVITIES

B.1 BACKGROUND

As part of this environmental assessment (EA), we evaluated the combined noise impacts of Army National Guard (ARNG), Coast Guard, and Air National Guard (ANG) activities. ARNG activities include training exercises at Camp Edwards involving the firing of small arms, artillery, mortar rounds, and demolition. ARNG activities also include training exercises using UH-1 and OH-6 helicopters. ANG activities currently involve training exercises with F-106 and T-33 fixed-wing aircraft. The Coast Guard uses HU-25 fixed-wing aircraft and HH-3 helicopters. Relevant to this assessment are changes in noise impacts that would result from the replacement of F-106 aircraft with F-16 or F-15 aircraft. The purpose of this appendix is to answer the following questions:

- How do the current noise environments created by the ARNG, Coast Guard, and ANG interact in the communities surrounding the Camp Edwards/Otis ANGB area?

- How would this current environment change if the F-106 aircraft were replaced by F-16 aircraft?

- How would this current environment change if the F-106 aircraft were replaced by F-15 aircraft?

- What are the changes in impacts due to the combined noise event energy levels *averaged over 24 h* (see Sec. B.2), as well as due to isolated *peak* noise event levels (see Sec. B.3).

Relative to the last item, DOD and U.S. Army policies mandate an evaluation of combined noise impacts by using the L_{dn} descriptor to implement the 24-h average concept. Those policies do not require further analysis; however, it was felt that a study of the combined impacts of ARNG and ANG *peak* noise events would provide an informative complement to the combined impacts analysis based on *24-h average* conditions.

It is assumed in the following analyses that the Camp Edwards Master Plan has been fully implemented. The noise environment for the ARNG activities is assumed to be that of the year 1990 or later, after the Camp Edwards training areas and activities (gunfire and helicopter flights) have been upgraded. ANG activities are represented by three alternatives: (1) the current situation with the F-106 and T-33 aircraft, (2) the conversion scenario with the F-16 aircraft, and (3) the conversion scenario with the F-15 aircraft. Coast Guard activities are assumed unchanged in 1990 from the current situation in which fixed-wing HU-25 aircraft and HH-3 helicopters are used for training and rescue missions.

The two separate methodologies used in this assessment to estimate the cumulative impact of these very different types of noise environments are discussed below.

B.2 METHOD 1: SUMMATION OF C-WEIGHTED ISOPLETHS (FROM ARNG IMPULSIVE NOISE) AND A-WEIGHTED ISOPLETHS (ANG AND COAST GUARD JET NOISE)

U.S. Army and DOD policy indicates that the combined impact of noises of different character (e.g., impulsive and broadband) is to be evaluated on a *24-h average* basis by the addition of component L_{dn} noise levels (Metcalf, 1977; Department of the Army, 1982). In the Otis ANGB/Camp Edwards case, this means that the C-weighted L_{dn} isopleths (impulsive noise from ARNG artillery activities) and A-weighted L_{dn} isopleths (ANG and Coast Guard activities) are to be added using logarithmic addition of decibel levels. This addition is to be carried out after adjustment of the C-weighted levels to "equivalent" A-weighted levels as described by the Department of the Army (1982). The noise contributions of the ARNG and Coast Guard helicopters, while in the vicinity of the base, can be shown to be insignificant compared with the contributions of the fixed-wing jets.

The C-weighted L_{dn} isopleths used in this assessment were prepared by the U.S. Army Environmental Hygiene Agency using the BNOISE computer model (Schomer et al., 1981). These C-weighted noise level predictions represent the estimated level of ordnance firing activities after completion of the Camp Edwards Master Plan in 1990. The BNOISE simulation model is used by the Army to assess noise impacts from large-caliber weapons. This computer program requires operational data for all weapons fired from each range or firing point, including demolition, the number and type of rounds fired from each weapon, the location of targets for each range or firing point, and the amount of propellant used to reach each target. The predicted utilization levels correspond to an approximate 30% annual expenditure rate of the ammunition assigned to regional ARNG units. C-weighted day-night noise levels from BNOISE reflect an acoustic energy average of activities that occur during one year. The data on ARNG firing for the year 1990 is preliminary and is based on projections that are likely to change as the Army noise management plan becomes more fully developed. However, as the details of firing activities and firing locations are likely to change, only those changes that will not enlarge the ARNG 62-B contour (see Fig. B.1) will be permitted (Stockhaus, 1986).

The A-weighted isopleths were prepared for this assessment assuming current conditions for the F-106 aircraft and then assuming that the conversion to F-16 or F-15 aircraft has occurred. These calculations were performed with the NOISEMAP computer model as described in the main text of this assessment. The NOISEMAP predictions reflect typical busy-day flying activities of the ANG.

To facilitate the summation of the ANG A-weighted L_{dn} contours with the ARNG C-weighted L_{dn} contours, the map of the Massachusetts Military Reservation and adjacent communities was divided into a grid of 500-m by 500-m squares. The boundary

lines of these squares intersect in a rectilinear pattern of points (nodes) spaced equally apart (500 m) from each other. Computer programs NOISEMAP and BNOISE were then rerun to generate separate printouts of the several thousand dB values (one at each node) for the air-operations A-weighted L_{dn} (using NOISEMAP) and ordnance C-weighted L_{dn} sound fields (using BNOISE), respectively. Predictions of NOISEMAP and BNOISE were thereby made on the same grid, allowing easy summation of values without special interpolation required. Next, by use of a special computer program developed at Argonne National Laboratory for that purpose, the C-weighted L_{dn} values of the BNOISE printout were converted to equivalent A-weighted values, using the conversion factors listed in Table B.1, given by the Department of the Army (1982). Then, at each of the several thousand nodes, the converted ordnance BNOISE dB value was logarithmically summed with the corresponding air-operations NOISEMAP dB value to obtain a single dB value for the combined sound fields. Finally, the summed noise levels over the entire grid were interpolated spatially to obtain isopleths at 5-dB intervals (Figs. B.2, B.4, and B.6).

TABLE B.1 Conversion of CDNL to Equivalent ADNL by Equal Annoyance[a]

Percent of Population Highly Annoyed	CDNL	ADNL	Percent of Population Highly Annoyed	CDNL	ADNL
1	45	45	14	61	64
2	46	49	16	62	65
2	47	49	18	63	67
2	48	49	20	64	68
3	39	52	23	65	69
3	50	52	25	66	70
3	51	52	28	67	72
4	52	54	32	3	73
4	53	54	35	o9	74
5	54	56	39	70	76
6	55	57	42	71	77
7	56	58	46	72	78
8	57	59	50	73	79
9	58	60	54	74	80
10	59	61	58	75	81
12	60	63			

[a]CDNL = C-weighted day-night noise level, in dB, from ARNG impulsive noise activities.

ADNL = A-weighted day-night noise level, in dB, from ANG and Coast Guard noise activities.

Source: Department of the Army, 1982.

Figure B.1 presents the C-weighted and A-weighted (F-106) noise contours before summation. Only the C-weighted 62-dB and 70-dB isopleths are plotted. Army Regulation 200-1, Chapter 7 (Department of the Army, 1982) implements all the federal policies concerning environmental noise for ARNG activities. This regulation defines three noise zones, with noise-sensitive land uses considered as follows:

- Zone I -- acceptable (< 62 dB, C-weighted)
- Zone II -- normally unacceptable (62-70 dB, C-weighted)
- Zone III -- unacceptable (>70 dB, C-weighted).

Figure B.1 shows that there is no overlap between the 65-dB L_{dn} isopleth for the aircraft noise and the 62-dB L_{dn} isopleth for the ARNG impulsive noise sources.

Figure B.2 shows the A-weighted results of summation of the C-weighted and A-weighted isopleths for the F-106 scenario. The calculations indicate that the ARNG activities dominate at Camp Edwards and the ANG activities dominate in the Otis ANGB vicinity. The noise levels from one do not affect the other, except for a small area to the northwest of the Otis ANGB runway area. In that locale, ANG and ARNG noise levels (on the A-weighted scale) are about equal. The summation of two equal levels adds only 3 dB. As a result, no major increase results, even in that area. In those locations where the 65-dB levels predicted by NOISEMAP for aircraft activities do cover community areas, the summation with ARNG noise levels does not result in a perceptible increase in noise levels. It should be stated that there is some uncertainty as to the precise location of the summed 65-dB contour because the U.S. Army BNOISE predictions could not be provided for this analysis on a grid smaller than 500 m x 500 m.

Figure B.3 presents the unsummed isopleths for the F-16 case and the ARNG activities, and Fig. B.4 presents the sum using the method of the Army (Department of the Army, 1982). The critical isopleths do not overlap (see Fig. B.3), and the summed isopleths using the F-16 predictions are smaller than the summed isopleths developed using the F-106. Similarly, Figs. B.5 and B.6 present the unsummed and summed isopleths, respectively, for F-15 flight operations and ARNG activities. The critical isopleths do not overlap (see Fig. B.5), and the summed isopleths using the F-15 predictions are smaller than the summed isopleths using the F-106. This method of analysis of combined impacts indicates the following:

- No overlap between critical noise isopleths occurs either on or off the Otis/Camp Edwards site for any of the three scenarios analyzed--F-106 scenario (present case), F-16 scenario, or F-15 scenario.
- The summation of NOISEMAP and BNOISE day-night level isopleths (using the U.S. Army methodology) leads to no significant change in the original NOISEMAP isopleths at off-site locations (for either the F-16 or F-15 case). As a result, the combined impacts off-site are essentially nil.

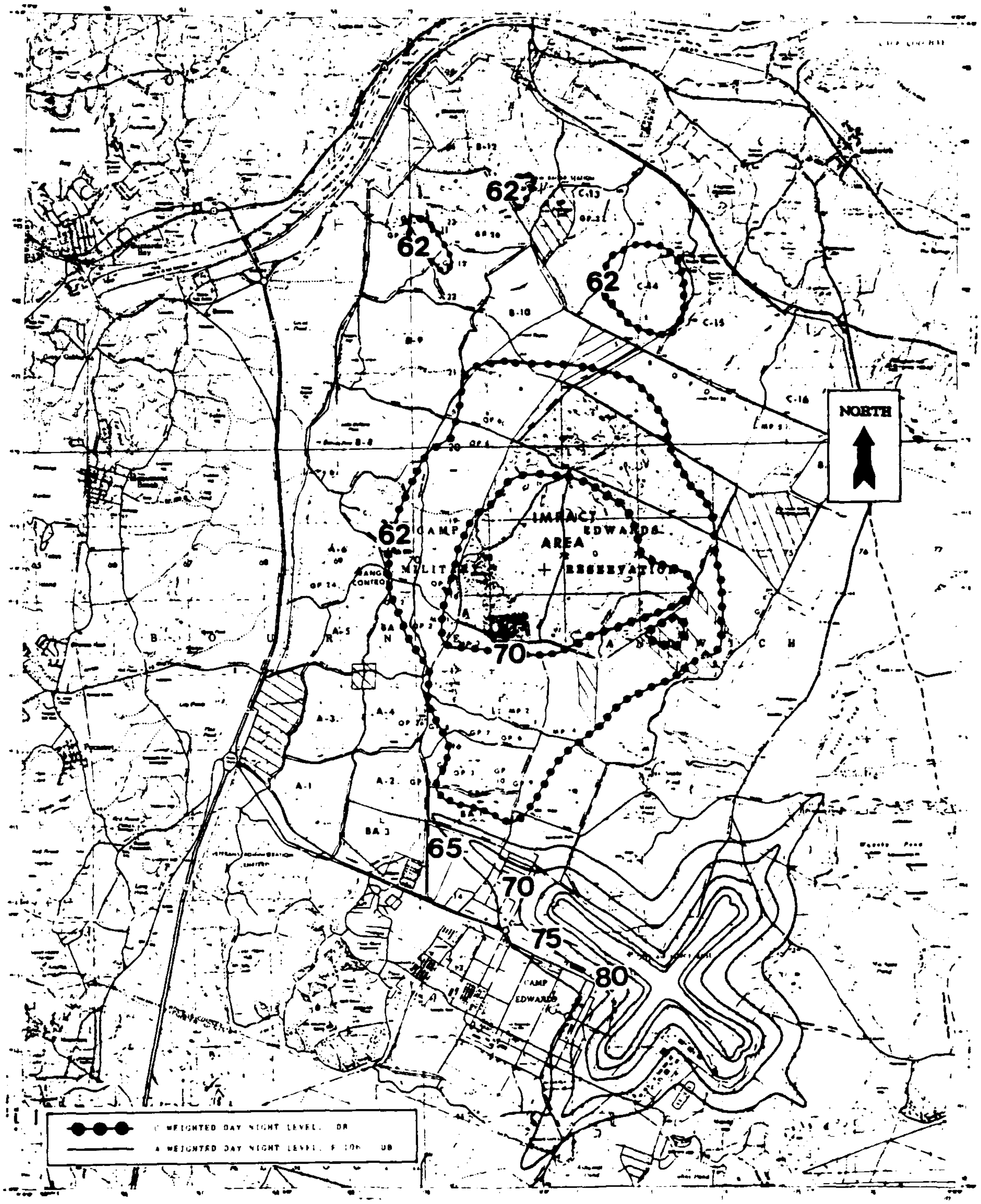

FIGURE B.1 Noise Contours from Air National Guard Activities (Otis ANGB F-106 Baseline) and Army National Guard Activities (Camp Edwards) (Isopleths are presented separately without summation)

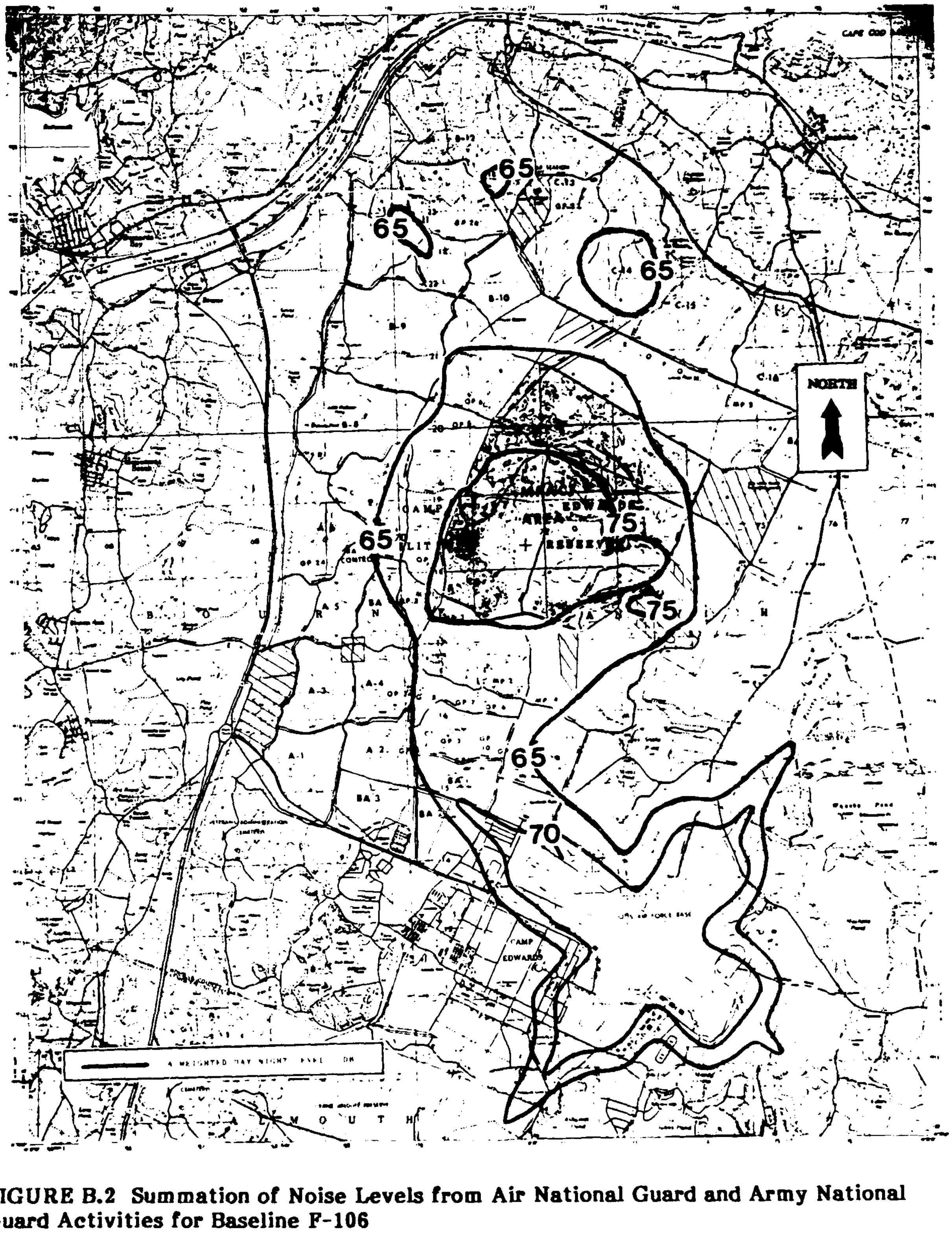

FIGURE B.2 Summation of Noise Levels from Air National Guard and Army National Guard Activities for Baseline F-106

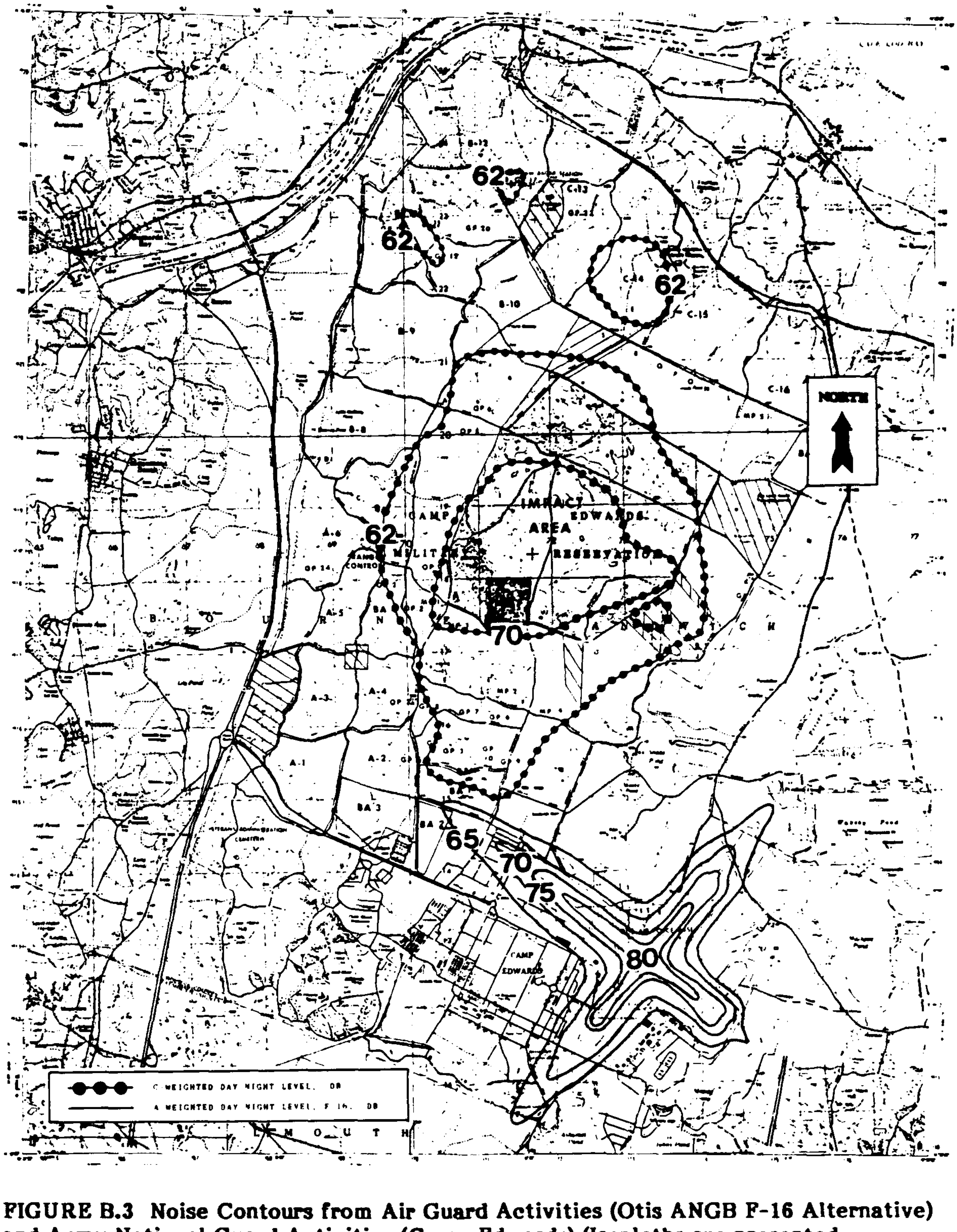

FIGURE B.3 Noise Contours from Air Guard Activities (Otis ANGB F-16 Alternative) and Army National Guard Activities (Camp Edwards) (Isopleths are presented separately without summation)

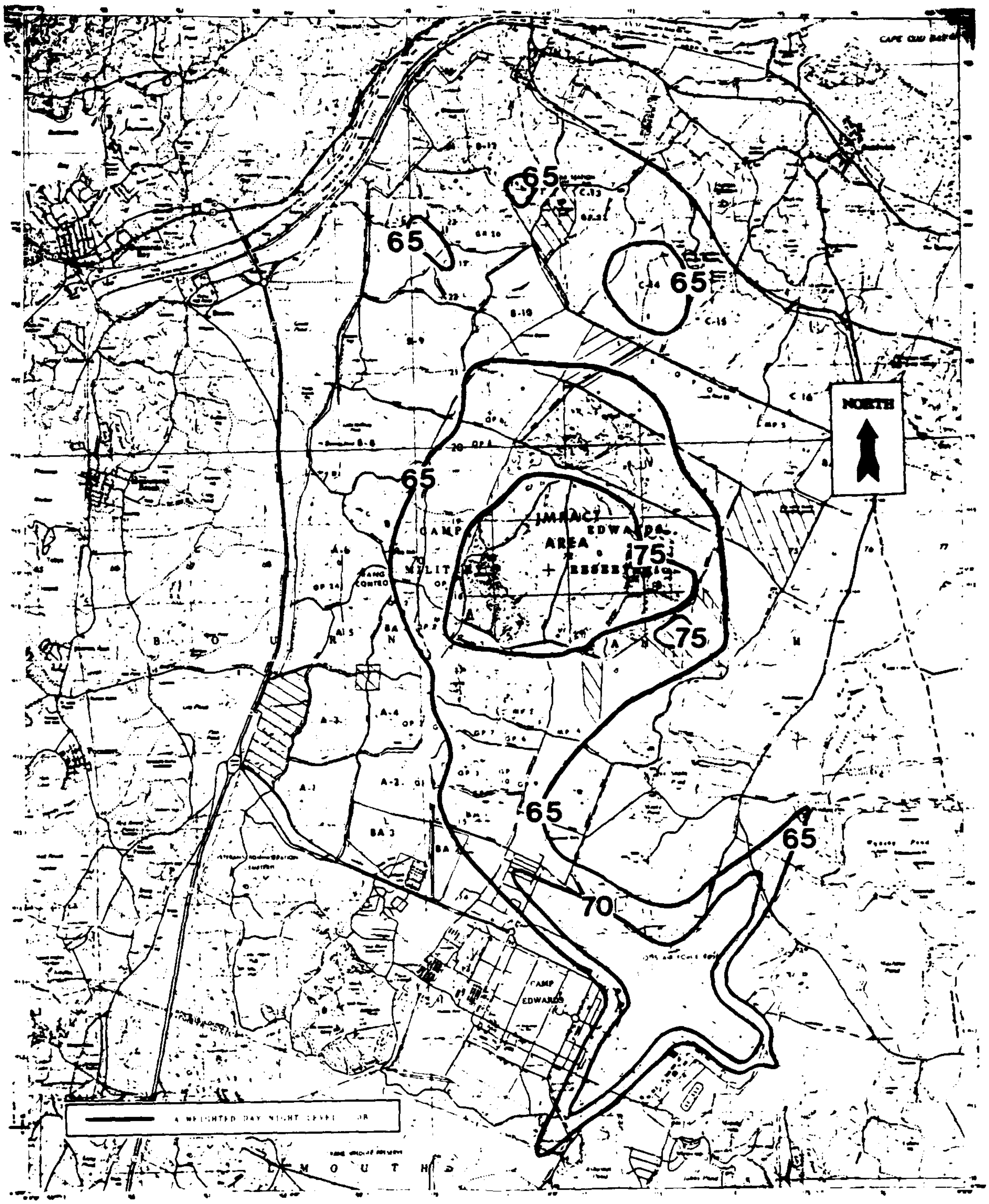

FIGURE B.4 Summation of Noise Levels from Air National Guard and Army National Guard Activities for F-16 Alternative

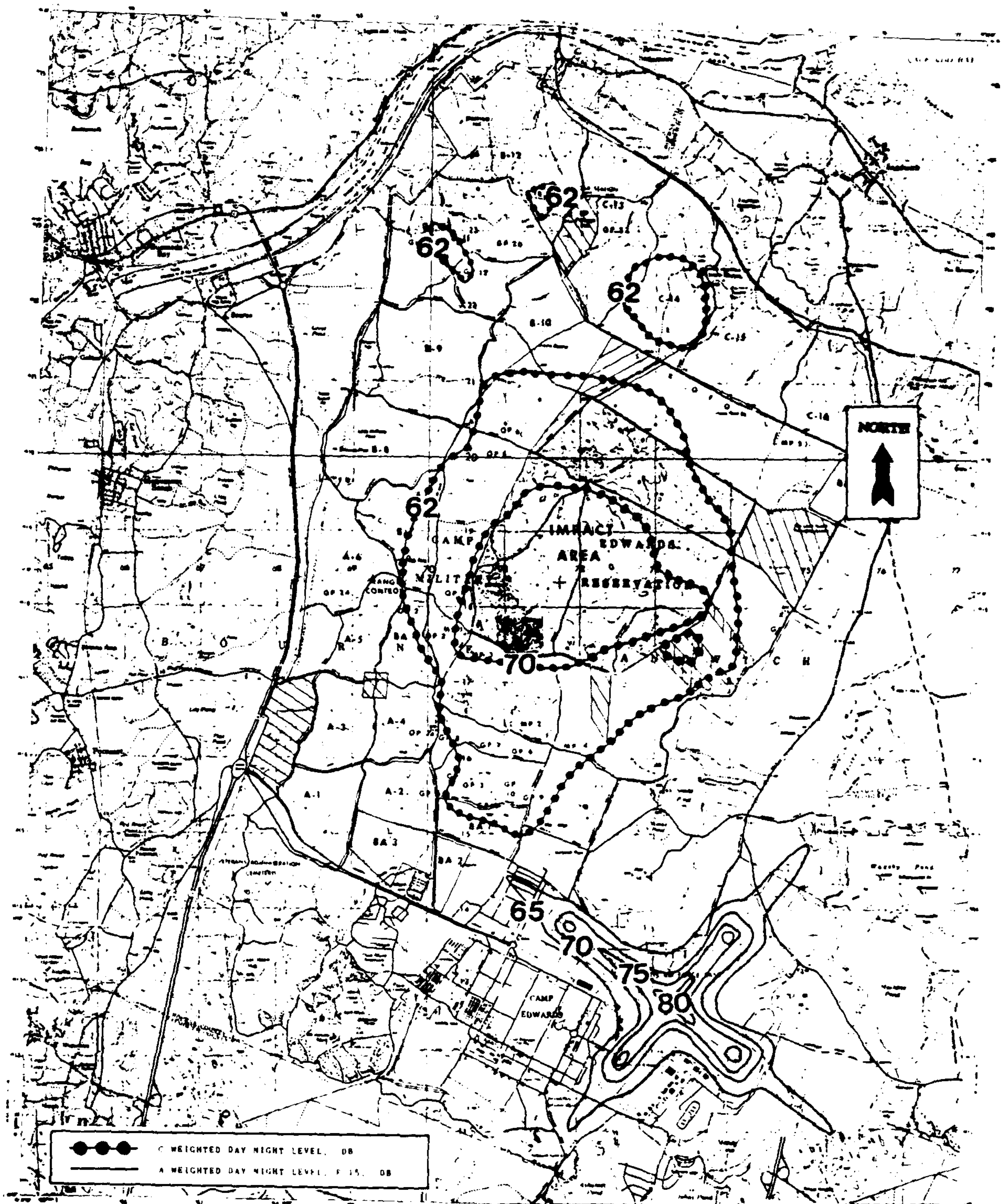

FIGURE B.5 Noise Contours from Air National Guard Activities (Otis ANGB F-15 Alternative) and Army *National Guard* Activities (Camp Edwards) (Isopleths are presented separately without summation)

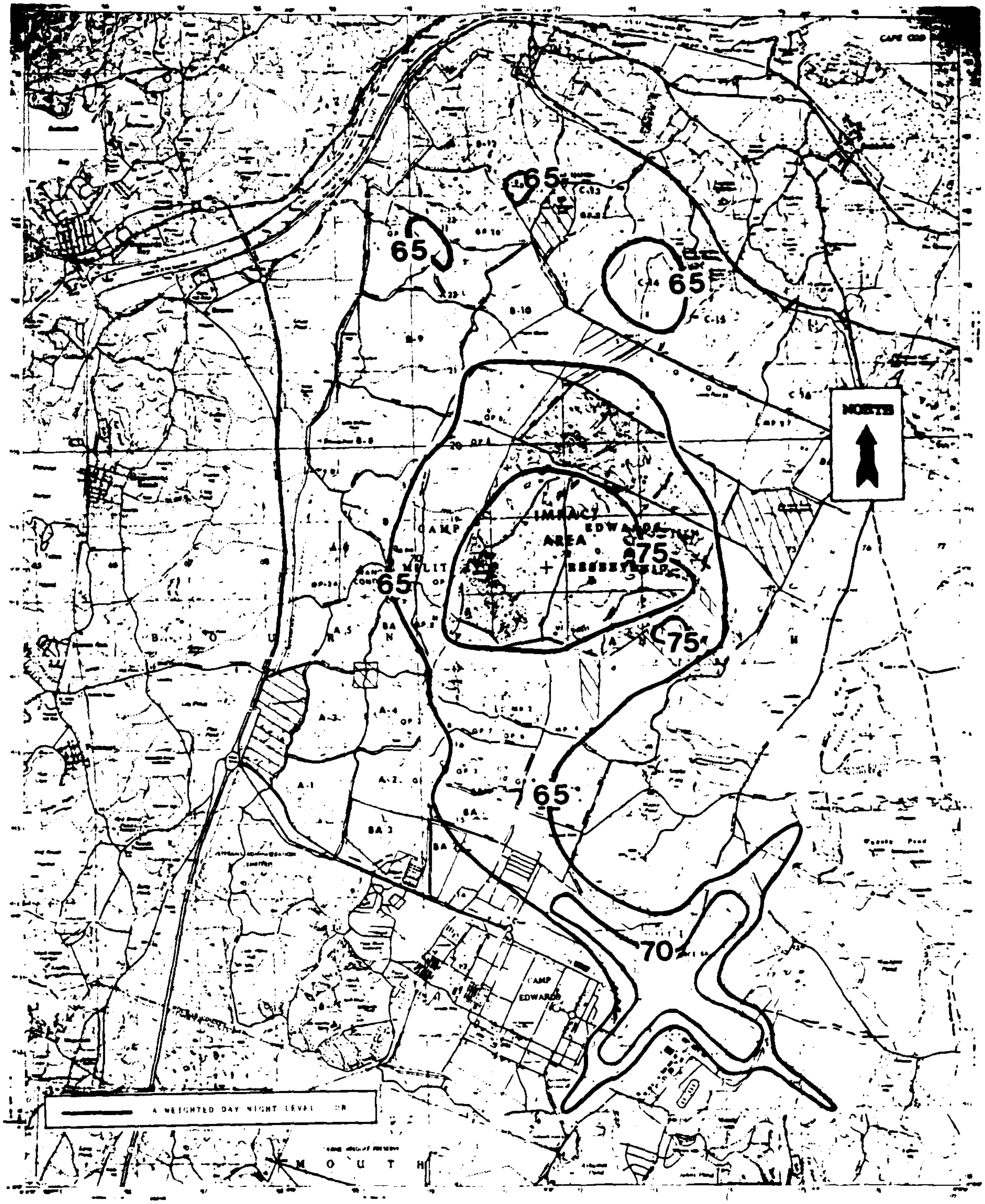

FIGURE B.6 Summation of Noise Levels from Air National Guard and Army National Guard Activities for F-15 Alternative

The methodology presented above, although representing U.S. Army and DOD policy, has not been scientifically validated; that is, no scientific studies have been published that provide comprehensive, conclusive evidence of the equivalence of the ADNL and CDNL scales for predicting the psychological stress of different kinds of noise relative to each other. Controversial issues surround the summation of A- and C-weighted levels and the interpretation of the summed isopleths in terms of community reaction. It was felt that an optional second approach to the combined impacts issue was warranted, even though not required by DOD policy. That second approach was to evaluate the effect of the aircraft conversion on peak noise events. That approach is described below.

B.3 METHOD 2: EVALUATION OF RELATIVE CONTRIBUTIONS TO COMMUNITY NOISE BETWEEN ARMY NATIONAL GUARD AND AIR NATIONAL GUARD SOURCES FOR PEAK NOISE SCENARIOS

B.3.1 Introduction

The objective of Method 1 was to evaluate the combined impacts of impulsive and broadband noise for an average day. Such an evaluation does not address peak noise events, however. Such peak events can lead to noise complaints. Complaints are triggered by short-term increases in noise above the average. Moreover, expected changes in peak impacts or complaint history cannot be analyzed by the modeling of average conditions. In this section, the effect of the conversion from F-106 to F-16 or F-15 aircraft is analyzed with respect to the effect on peak impacts. This analysis is intended to determine the extent to which the conversion from F-106 to F-16 or F-15 aircraft would increase or decrease the impacts of the associated peak noise events.

This is clearly a research issue. No computer program exists to determine the community reaction (or changes in community reaction due to F-16 or F-15 conversion) from multiple noise sources of different character, e.g., jet noise, artillery noise, and helicopter noise. Discussions with Camp Edwards personnel indicated that overlapping noise activities occur frequently for residents in the surrounding community. A special methodology was developed to evaluate the impact of such short-term single events. This methodology, as it relates to Army noise, involves the choice of four scenarios representing typical complaint situations. These scenarios are listed in Table B.2, and four community residential locations (receptor locations 1-4) most affected by those four ARNG operational noise scenarios are shown in Fig. B.7. Each scenario includes not only impulse noise (e.g., gunfire, howitzers), but also helicopter activity and a jet flying overhead. Table B.3 lists the flight profiles and Table B.4 the characteristics of the F-106, F-16, and F-15 jets in these scenarios. The jets were assumed to be in the noisiest phase of flight -- departure for the F-106 and F-16 and approach for the F-15. The helicopters at Camp Edwards may fly anywhere once they are off the base (except they avoid the southeastern portion of Camp Edwards for noise-abatement purposes). It was assumed that a helicopter was positioned at 500 m, 1,000 m, or 2,000 m horizontally from any one of 11 targeted community locations. Table B.5 lists the noise source

TABLE B.2 Description of the Four Critical ARNG Noise Scenarios

All four scenarios have the same fixed-wing and helicopter activity present. A single fighter aircraft (either a F-106, F-16, or F-15) departs the base on any runway. At a later time, an F-15 fighter lands on Runway 23. At the same time, an F-15 fighter lands on any runway. At the same time, a single ARNG UH-1 (Bell 212) helicopter or a single Coast Guard HH-3 (Sikorsky 61) helicopter is traveling at an altitude of 670 ft above ground level, at 80 or 70 knots, respectively. The helicopter is at a horizontal distance of 500 m, 1,000 m, or 2,000 m from the receptor location being analyzed (see Fig. B-7).

Scenario I. Demolition

An uncovered 40-lb C-4 shaped demolition charge is detonated at the bottom of a 65-ft-deep pit at Engineer Demolition Range E-2. Noise levels of the blast are of special concern at three Sandwich locations (in Shawme-Crowell State Forest, Forestdale, and at residences near Snake Pond), especially in relation to the use of either F-106, F-16, or F-15 aircraft.

Scenario II. Mortar

A single 107-mm mortar is fired at a time at any of four mortar-firing ranges (MP-1, MP-2, MP-3, or MP-4). The propellant and shell-filling charges are 5.39 oz and 92 oz, respectively. Mortar muzzle-blast and explosive-shell impact noise at the same three Sandwich locations is also of particular concern, along with noise from F-106, F-16, or F-15 aircraft operation.

Scenario III. Machine Gun

A single 0.50-caliber machine gun is fired in bursts of 5 or 6 rounds, at 5- to 10-second intervals,[a] at Firing Range A. Each round contains 0.51 oz. of powder. The machine gun noise is of particular concern in Bourne, compared with F-106 or F-16 fighter flight operations.

Scenario IV. Howitzer

Either a single 105-mm howitzer is firing live (HE deep-cavity, zone 3) shells, or a single 155-mm howitzer is firing nonexplosive shells from either Range GP-14 or GP-16. Maximum propellant charges used are 29.85 oz and 112.8 oz for the 105-mm and 155-mm shells, respectively. The 105-mm HE shell contains 81.28 oz. of explosive. Muzzle-blast noises are of particular concern in Bourne, as well as explosive-shell impact both there and at all locations in Sandwich, in relation to F-106, F-16, or F-15 aircraft operation.

[a]A maximum repetition rate of 550 rounds per minute (8 rounds per second).

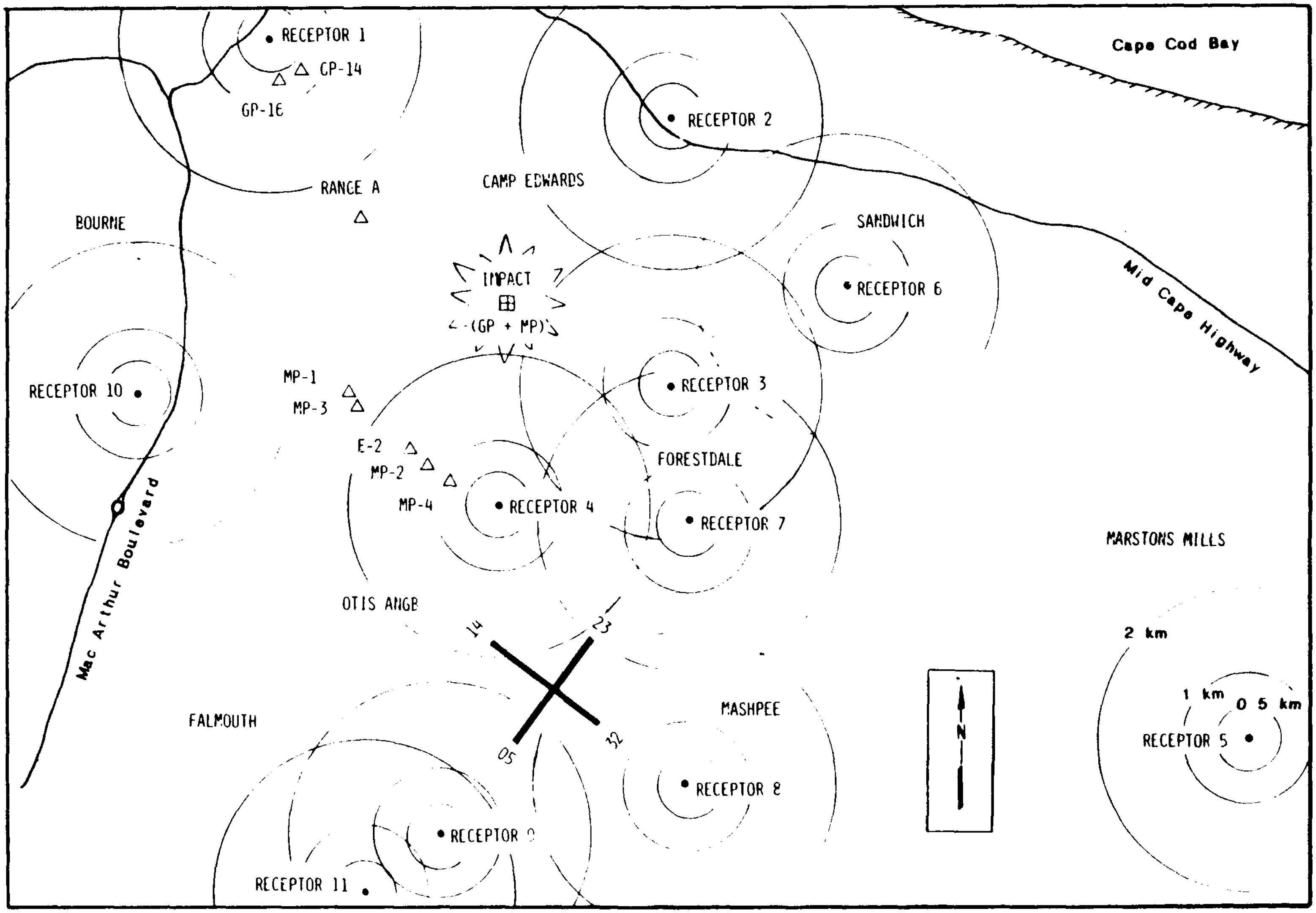

FIGURE B.7 Sketch Showing 11 Community Residential Locations along with Fixed-Wing, Helicopter, and Gun-Firing Positions According to Scenarios Defined in Table B.2

TABLE B.3 Fighter Aircraft Flight Profiles

Scenario	Distance from Runway[a] (nautical miles)	Altitude (feet above ground level)
Departures		
F-106	0	0
	0.75	0
	1.5	370
	2.5	870
	3.33	1,670
	4.17	2,370
	5.0	3,170
	6.67	4,870
F-16	0	0
	0.375	0
	1.33	300
	2.0	600
	3.0	1,600
	4.0	2,700
	5.0	3,850
F-15	0	0
	0.38	0
	1.0	400
	2.0	1,500
	3.0	2,500
	4.0	4,000
	6.0	6,500
Approaches		
F-15	50	5,000
	10	1,550
	5.0	1,400
	1.0	400
	0.75	170
	0	50

[a]For departures, distance is from start of runway; for approaches, distance is from end of runway.

TABLE B.4 Fighter Aircraft Power Settings and Airspeeds

Aircraft/Operation	Distance (nautical miles)	Power Setting (% rpm)	Airspeed (knots)
F-106 Departure			
With afterburner	0-<1.5	108	250
Without afterburner	1.5-<2.5	101	310
	2.5-<6.67	95	310
	≥6.67	101	400
F-16 Departure[a]	0-<0.38	90	240
	0.38-<1.33	90	240
	1.33-<2.0	90	275
	2.0-<3.0	90	350
	3.0-<4.0	90	395
	≥4.0	90	400
F-15 Departure[a]	0-<0.38	88	140
	0.38-<1.0	88	300
	≥1.0	82	300
F-15 Approach	0-<5.0	74	160
	5.0-<10	78	160
	≥10	74	250

[a]Without afterburner.

TABLE B.5 Coordinates of Noise Sources (jets, helicopters, gunfire)

Scenario	Source Description	Coordinates[a] (meters) x	y	z
I	40 lb C-4 65 feet deep in pit	6,470	7430	45.7
II	Mortar muzzle at MP-1	5,800	8400	58.0
II	Mortar muzzle at MP-2	6,580	7180	43.7
II	Mortar muzzle at MP-3	5,860	8250	55.9
II	Mortar muzzle at MP-4	7,100	6980	49.8
III	0.50-caliber machine gun at Range A	5,900	11,300	49.4
IV	Howitzer gun muzzle at GP-14	5,220	13,800	48.7
IV	Howitzer gun muzzle at GP-16	5,050	13,710	50.2
II,IV	Shell Impact Zone	7,800	9,800	61.0
I-IV	F-106 afterburner cutoff nearest R1	7,250	4,560	153.6
I-IV	F-106 afterburner cutoff nearest R2	9,610	4,700	146.3
I-IV	F-106 afterburner cutoff nearest R3	9,610	4,700	146.3
I-IV	F-106 afterburner cutoff nearest R4	7,250	4,560	153.6
I-IV	F-106 afterburner cutoff nearest R5	9,460	2,800	146.3
I-IV	F-106 afterburner cutoff nearest R6	9,610	4,700	146.3
I-IV	F-106 afterburner cutoff nearest R7	9,610	4,700	146.3
I-IV	F-106 afterburner cutoff nearest R8	9,400	2,800	146.3
I-IV	F-106 afterburner cutoff nearest R9	7,680	2,370	143.3
I-IV	F-106 afterburner cutoff nearest R10	7,250	4,560	153.6
I-IV	F-106 afterburner cutoff nearest R11	7,680	2,370	143.6
I-IV	F-106 takeoff nearest R1	1,040	9,540	1,254
I-IV	F-106 takeoff nearest R2	13,840	9,800	1,063
I-IV	F-106 takeoff nearest R3	11,680	7,180	529.5
I-IV	F-106 takeoff nearest R4	6,730	4,970	217.5
I-IV	F-106 takeoff nearest R5	14,490	-1,200	984.5
I-IV	F-106 takeoff nearest R6	13,230	9,060	885.9
I-IV	F-106 takeoff nearest R7	10,190	5,410	209.2
I-IV	F-106 takeoff nearest R8	10,350	2,080	237.9
I-IV	F-106 takeoff nearest R9	7,010	1,580	187.6
I-IV	F-106 takeoff nearest R10	2,660	8,200	919.9
I-IV	F-106 takeoff nearest R11	5,700	0	492.2
I-IV	F-16 takeoff nearest R1	1,040	9,540	1,201
I-IV	F-16 takeoff nearest R2	13,840	9,800	1,237
I-IV	F-16 takeoff nearest R3	11,680	7,180	616.7
I-IV	F-16 takeoff nearest R4	6,730	4,970	212.8
I-IV	F-16 takeoff nearest R5	14,490	-1,200	1,175
I-IV	F-16 takeoff nearest R6	13,230	9,060	1,069
I-IV	F-16 takeoff nearest R7	10,190	5,410	203.2
I-IV	F-16 takeoff nearest R8	10,350	2,080	257.8
I-IV	F-16 takeoff nearest R9	7,010	1,580	231.7
I-IV	F-16 takeoff nearest R10	2,660	8,200	1,113
I-IV	F-16 takeoff nearest R11	5,700	0	576.6
I-IV	F-15 takeoff nearest R1	1,040	9,540	1,951
I-IV	F-15 takeoff nearest R2	13,840	9,800	1,705

TABLE B.5 (Cont'd)

Scenario	Source Description	Coordinates[a] (meters) x	y	z
I-IV	F-15 takeoff nearest R3	11,680	7,180	922.5
I-IV	F-15 takeoff nearest R4	6,730	4,970	468.7
I-IV	F-15 takeoff nearest R5	14,490	-1,200	1,623
I-IV	F-15 takeoff nearest R6	13,230	9,060	1,484
I-IV	F-15 takeoff nearest R7	10,190	5,410	476.0
I-IV	F-15 takeoff nearest R8	10,350	2,080	532.1
I-IV	F-15 takeoff nearest R9	7,010	1,580	506.0
I-IV	F-15 takeoff nearest R10	2,660	8,200	1,532
I-IV	F-15 takeoff nearest R11	5,700	0	874.4
I-IV	F-15 approach nearest R1	1,040	9,540	386.5
I-IV	F-15 approach nearest R2	13,840	9,800	394.2
I-IV	F-15 approach nearest R3	11,680	7,180	234.5
I-IV	F-15 approach nearest R4	6,730	4,970	75.6
I-IV	F-15 approach nearest R5	14,490	-1,200	313.5
I-IV	F-15 approach nearest R6	13,230	9,060	332.9
I-IV	F-15 approach nearest R7	10,190	5,410	68.3
I-IV	F-15 approach nearest R8	10,350	2,080	68.6
I-IV	F-15 approach nearest R9	7,010	1,580	78.2
I-IV	F-15 approach nearest R10	2,660	8,200	317.2
I-IV	F-15 approach nearest R11	5,700	0	211.2
I-IV	Helicopter at 500 m offset[b]	0	500	204.2
I-IV	Helicopter at 1000 m offset[b]	0	1,000	204.2
I-IV	Helicopter at 2000 m offset[b]	0	2,000	204.2

[a]The origin (x = 0, y = 0) is near the southwestern corner of the Pocasset Quadrangle (USGS map) at UTM coordinates N4,609,200, E364,650 (proximate to latitude 41 deg, 37 min, 30s; longitude 70 deg, 37 min, 30 s). x corresponds to east from origin; y corresponds to north from origin; and z corresponds to height above mean sea level.

[b]The receptor coordinates are the origin for these coordinate values.

coordinates, and Table B.6 describes the 11 residential receptor locations studied and lists their coordinates. The origin (x = 0, y = 0) is near the southwestern corner of the Pocasset Quadrangle (USGS map), located at UTM coordinates N4,609,200, E364,650 (proximate to latitude 41 deg, 37 min, 30 s; longitude 70 deg, 37 min, 30 s). All elevations (z) are given in meters above mean sea level (MSL).

As stated above, receptor locations 1-4 were selected because of their proximity to ARNG activities. The remaining seven receptor locations were selected to include four community locations where ANG jet noise is likely to predominate (receptor locations 7-9 and 11) and three (receptor locations 5, 6, and 10) where both the ANG and ARNG noise levels were expected to be about equal. It is believed that the entire set of 11 community locations (1) provides a good cross section of community areas that have a potential for peak short-term noise impacts from either ANG or ARNG activities, and (2) represents a balance between locations where ANG and ARNG peak noise predominates. In summary, four locations (receptor locations 1-4) were initially selected where it was assumed that Army noise might predominate, four locations (receptor locations 7-9 and 11) where ANG noise is likely to predominate, and three locations (receptor locations 5, 6, and 10) where it was expected that both the Army and ANG noise would likely provide equal loudness during peak noise episodes.

The Army noise scenarios modeled are somewhat anecdotal in nature since detailed records of Camp Edwards activities relating to peak noise events or complaint history is lacking. They represent the informal judgment of on-site ARNG personnel at Camp Edwards as to the scenarios that tend to lead to noise complaints. These scenarios, although obtained from past ARNG experience, are likely to occur in the year 1990 after implementation of the Camp Edwards Master Plan. A study of these ARNG operational (noise) scenarios is incomplete without a presentation of their frequencies of occurrence, as summarized in Table B.7. The data used for the table are from the same data base used by the Army in the BNOISE computer run for an average day in 1990. It should be noted that many of the explosion events listed in Table B.7 occur on weekends, while most of the ANG activities occur on weekdays. ANG activities occur on weekdays plus three weekend days per month. As a result, the potential for overlapping noise activities is not as great as would be the case if all activities of the ARNG and ANG were on weekdays only. ANG activities (on a daily basis) are presented in Table 4.2. In any case, overlapping (ARNG and ANG) noise events (weekdays and weekends) can occur frequently in the vicinity of the Massachusetts Military Reservation.

The ANG noise scenario modeled in this study represents the noisiest operation of the assigned fighter jets:

- two-craft departure (with afterburner) for the F-106 from any of the four runways,

- two-craft departure for the F-16 from any of the four runways, and

- two-craft approach for the F-15 to any of the four runways.

TABLE B.6 Description of Selected Residential Receptor Locations

Receptor No.	Receptor Coordinates[a] (meters) x	y	z	Description
1	4,830	14,280	41.3	Bourne--point on property line near residences on Route 6W nearest gun firing ranges and Jefferson Road
2	10,330	12,770	50.5	Sandwich--residence in Shawme-Crowell State Forest, just north of Mid Cape Highway nearest shell-impact area
3	10,090	8,510	50.5	Sandwich--Forestdale residence nearest to shell-impact area, in new housing development along Greenway Road
4	7,890	6,440	44.4	Sandwich--nearest residence to Demolition Range E-2 and mortar firing positions, in new housing development west of Snake Pond
5	17,500	2,570	10.8	Barnstable/Marstons Mills--inter-section of Routes 28 and 149
6	13,230	9,060	41.3	Sandwich--residence on Runway 05 centerline, near Spectacle Pond
7	10,190	5,410	23.0	Sandwich--residence on Runway 05 centerline, near Pimlico Pond
8	10,350	2,080	24.5	Mashpee--residential area under construction on Runway 14 centerline, between Moody and Washburn Ponds
9	7,260	1,360	23.0	Mashpee--residence near Runway 23 centerline and Ashumet Pond
10	2,660	8,200	29.1	Bourne--Pocasset residence on Runway 32 centerline, near Upper Pond
11	5,410	220	23.0	Falmouth--Hatchville residence near Runway 23 centerline

[a]The origin (x = 0, y = 0) is near the southwestern corner of the Pocasset Quadrangle (USGS map) at UTM coordinates N4,609,200, E364,650 (proximate to latitude 41 deg, 37 min, 30s; longitude 70 deg, 37 min, 30 s). x corresponds to east from origin; y corresponds to north from origin; and z corresponds to height above mean sea level.

TABLE B.7 Occurrence of Ordnance Firings for Army Scenarios Used in Otis ANGB Noise Assessment[a]

Location[b]	Noise Source	Firings per Year Daytime	Firings per Year Nighttime	Firings per Year Total
Scenario I (Demolition)				
E-2	40 lb C-4	c	c	c
Other E	40 lb C-4	c	c	c
Scenario II (Mortar Fire)[d]				
MP-1	107-mm mortar	265	15	280
MP-2	107-mm mortar	265	15	280
MP-3	107-mm mortar	265	15	280
MP-4	107-mm mortar	177	10	187
MP-1	All other mortars	500	24	534
MP-2	All other mortars	500	34	534
MP-3	All other mortars	500	34	534
MP-4	All other mortars	334	22	356
All other MP	107-mm mortars	786	40	826
All other MP	All other mortars	3,882	262	4,154
Scenario III (Machine-Gun Fire)				
A	0.50-cal. MG	89	22	111
A	All other MG	76	0	76
All other	0.50-cal. MG	0	0	0
All other	All other MG	54	20	74
Scenario IV (Howitzer Fire)[e]				
GP-14	105-mm How.-HE	50	0	50
GP-14	155-mm How.-LITR	130	0	130
GP-14	All other How	N/A	N/A	N/A
GP-16	105-mm How.-HE	33	0	33
GP-16	155-mm How.-LITR	130	0	130
GP-16	All other How	N/A	N/A	N/A
All other GP	105-mm How.-HE	1,474	0	1,474
All other GP	155-mm How.-LITR	2,336	0	2,336
All other GP	All other How.	N/A	N/A	N/A

TABLE B.7 (Cont'd)

Location[b]	Noise Source	Firings per Year Daytime	Nighttime	Total
All Other Firings[f]				
All	All other nonmodeled sources	1,420	0	0

[a]Scenarios are described in Table B.2.

[b]Firing range designation.

[c]Over the past six years, there has been an average of twenty 40-lb shaped charges exploded per year. However, the Army National Guard is tentatively projecting no demolition charges in 1990. This projection is currently being evaluated by Camp Edwards Base personnel to determine the impacts on training. If demolition is placed back on the 1990 agenda, this demolition would take place over 92 days, 80 of which are weekend days. If demolition is returned to the firing agenda, other gunfire activities will need to be removed to ensure that the 62-dBC contour does not expand off the reservation.

[d]The mortar fire takes place over a window of 92 days, 80 of which are weekend days.

[e]Howitzer fire takes place only on 33 weekends, i.e., 66 weekend days. Firing is reduced in the summer, with none carried out in July and August.

[f]A total of 1,294 events involve the AVCO (a DOD contractor at the base) testing program where a wide variety of explosives are used. This number is based on historical records (from 1985). The AVCO program is carried out in a period of 260 days per year, all weekdays. In addition, the ARNG would have 126 explosive events over a period of 92 days per year. This 92-day period encompasses 41 weekends (82 days) plus 10 weekdays (2 weeks of annual training).

The three-step calculational methodology is described briefly as follows:

Step 1—Calculate Source Emissions: For each of the three source types (jet, helicopter, ordnance), a 1/3-octave-band sound power spectrum was computed. For the F-106, F-16, and F-15 jets, this source sound power spectrum was computed for each power setting and speed of the aircraft assumed at each source location in Table B.4.

Step 2—Calculate Sound Pressure Levels at Receptors: Based on the sound power spectra data computed in Step 1 and a sound propagation model, unweighted sound pressure level spectra due to noise from the helicopters, jets, and ordnance were computed at each of the 11 receptor locations. Standard-day conditions were assumed for simplicity.

Step 3—Compute Loudness due to Each Source Contribution: For each of the source categories (and each of the receptor locations), the loudness (in sones) was calculated using the Stevens Mark VII model (Stevens, 1972). The resulting sone values, which are proportional to the magnitude as perceived by human hearing, were then plotted as bar charts. For each receptor location, one bar chart provides predictions of the maximum perceived magnitude (loudness) due to each of the noise emission sources: F-106 (afterburner and takeoff), F-16 (takeoff), F-15 (takeoff and approach), demolition, 107-mm mortar (muzzle and shell impact), machine gun, 105-mm howitzer (muzzle and shell impact), 155-mm howitzer (muzzle only). In terms of sones, the height of the bars is directly proportional to the perceived magnitude (loudness) to the human ear. One bar twice as high as another bar indicates noise that sounds twice as loud.

The Stevens loudness model has been *found* to be the superior index of sound magnitude (as distinguished from annoyance). An indicator of annoyance was not used here to combine impulsive and broadband sources because there is no agreement in the literature as to how that can be done effectively. Annoyance involves an integration of impulses and broadband sounds over an appreciable time interval (1 hour, 1 day, etc.). In the present analysis, however, the comparison is made of each source contribution at each receptor on the basis of its subjective/perceived maximum magnitude. It should be recognized that the noise of a jet or helicopter will maximize for a few seconds or more when heard, whereas the impulsive sound of gunfire occurs over a fraction of a second. Even in the gunfire scenarios, multiple shots are fired for each of the four scenarios (except Scenario I, Demolition). Multiple shots will not have any effect on the maximum noise level presented here, yet will contribute to annoyance, which is not calculated here. As indicated above, a qualified means of predicting annoyance for combined helicopter, jet, and gunfire noise remains a research issue.

B.3.2 Detailed Description of Modeling Steps

Now that a general description has been provided for the steps involved in the modeling, specific details are given below.

Step 1. Calculate Source Emissions

It is necessary to determine a 1/3 octave-band sound power level spectrum for each source as a starting point for the propagation and loudness calculations. The procedure is fundamentally different for relatively steady (aircraft) sound sources as compared with impulsive (explosive) sound sources as described below. Human hearing requires at least 0.5 second to sense loudness consistently (Kryter, 1984). This and other practical considerations in the measurement of environmental noise (which fluctuates in instantaneous amplitude very randomly) has resulted in the adoption of 1 second as the basic period of time used to integrate noise energy for psychometric purposes (Kryter, 1970, 1984). Therefore, the loudness of impulsive sounds lasting less than 1 second must be calculated from a 1-second-integrated energy value, i.e., the *1-second sound exposure level* (SEL). Such sounds include single rounds and short bursts of machine-gun fire, as well as single rounds of large-caliber weapons and explosives at close range. The maximum loudness of sounds that are essentially constant in level, or are relatively constant within a 1-second period, even though they rise and fall within a time period of many seconds (e.g., aircraft flyovers) is calculated from the *maximum sound pressure level*, i.e., the maximum level measured in any 1-second period.

Step 1A. Calculate Sound Power Level Spectra for Aircraft. U.S. Air Force and Federal Aviation Administration (FAA) publications that present mean unweighted 1/3 octave-band sound pressure level spectra as a function of slant distance from the source are used. From these tables, equivalent sound power level spectra are computed, i.e., sound power spectra for an isotropic source in free space that would yield the same sound pressure level spectra contained in the Air Force or FAA tables using a standard propagation model. The specific references used for calculation of the aircraft sound sources are as follows:

Aircraft Reference Operating Conditions	References (all by Speakman et al.)
F-106; 108% power setting, 350 knots	1978b, p. 253
F-106; 106% power setting, 350 knots	1978b, p. 262
F-16; 90% power setting, 350 knots	1978a, p. 424
F-15; 90% power setting, 300 knots	1978a, p. 362
F-15; 75% power setting, 170 knots	1978a, p. 380

The sound propagation model used to calculate source sound power is in accordance with Beranek (1971) and Bolt Beranek and Newman, Inc. (1984, Chapter 5) using air-to-ground air attenuation factors derived from the Air Force data cited above. A more detailed commentary on this procedure is given in the Step 2 discussion. No complex meteorological or terrain information is accounted for; i.e., a homogeneous atmosphere is assumed at 15°C and 70% relative humidity.

Step 1B. Calculate Sound Power Level Spectra for Impulsive Sources (Explosives and Weapons). Spectra for impulsive noise sources are not commonly published. From classical references (Kryter and Garinther, 1965; Snow, 1967; Kryter, 1970; Schomer et al., 1976), an idealized spectrum shape is developed by assuming that above a corner frequency, the spectrum slopes downward at the rate of 6 dB per octave and that below the corner frequency, the slope is either flat (no underpressure) or positively sloped. A +3 dB per octave slope (Kryter, 1970) is chosen for the sources modeled in this study. The value of the corner frequency is calculated from a formula provided by Schomer et al. (1976). The next step involves the use of Fig. 16 in Schomer et al. (1981). That reference provides a graph of C-weighted sound exposure levels (CSEL) (at 250 m from the blast) versus powder weight, for a wide range of weapon types. For all of our blast scenarios (40-lb C-4 demolition charge; 105-mm howitzer muzzle blast and shell impact; 155-mm howitzer muzzle blast; and 107-mm mortar blast and shell impact), the CSEL value at 250 m is read from that Fig. 16. At that point, the amplitude of the spectrum is adjusted (effectively moved up or down on a decibel versus 1/3 octave-band plot) until its C-weighted value becomes equal to that read from the Fig. 16 graph.

In the case of the 0.50-caliber machine-gun bursts of less than 1-second duration, the procedure is essentially the same except the A-weighted sound-exposure-level (SEL) of a single round is obtained from McBryan (1978). Calculation of the loudness of an automatic weapon (i.e., one that fires more than one round per second) requires that a special correction of 10 log (rounds/second) be made to the single-round sound level for each multiple-round burst (Kryter, 1984). A maximum firing repetition rate of 550 rounds per minute (8 rounds per second) is specified for the 0.50-caliber machine gun (U.S. Army, 1972); however, in this scenario a burst of only 5 to 6 rounds is typical.

Finally, the 1/3 octave-band sound pressure level spectrum is converted into a sound power level spectrum, accounting for the atmospheric attenuation that occurs to the blast acoustic source over the 250-m distance (see Step 2). This procedure for estimating a 1/3-octave-band sound power level spectrum is repeated for each of the blast sources. The following references are used in these calculations:

Impulsive Source	Reference
40-lb C-4 demolition charge	Schomer et al., 1976 and 1981
105-mm howitzer muzzle blast	Little et al., 1981; Frederick, 1986; Schomer et al., 1981
105-mm HE shell impact	Schomer et al., 1981; U.S. Army, 1969
155-mm howitzer muzzle blast	Little et al., 1981; Frederick, 1986; and Schomer et al., 1981
107-mm mortar muzzle blast	Schomer et al., 1981; U.S. Army, 1969; Lewis, 1986
107-mm mortar shell impact	Schomer et al., 1981; U.S. Army, 1969
0.50-caliber machine gun	Luz, 1983; McBryan, 1978; U.S. Army, 1972

It should be noted that the sound power spectrum of the demolition charge requires special reduction to account for the noise attenuation due to the location of the charge in a pit. The attenuation is calculated using a computer code implementing the barrier method given in Piercy et al., 1979.

Step 1C. Calculate Sound Power Level Spectra for Helicopters. The reference sound pressure level spectrum for the UH-1 helicopter is found in Raspet et al. (1984, Fig. 8, p. 20), which provides measured maximum A-weighted 1/3 octave-band levels for level flight at a slant distance of 110 m. These data are first unweighted, and then an equivalent sound power spectrum (for an isotropic source in free space) is calculated; i.e., an isotropic source in free space is determined that would yield the same sound pressure level spectrum as given in the Raspet reference for a distance of 110 m from the source, using a propagation model as described in detail in Step 2. Using this sound power level spectrum, sound pressure level spectra are calculated for slant distances of 125, 250, 500 and 1000 m; these are A-weighted and logarithmically summed to obtain overall A-weighted levels. These levels, in turn, are checked against values given in Figure 17, p. 33, of Raspet et al. (1984) for *LEQ Measure* and *LEQ Calculated* to verify accuracy of the calculation model. The sound power level spectrum and propagation model thus verified is then used to calculate sound pressure level spectra at slant distances of 540, 1,021, and 2,010 m (corresponding to projected horizontal receptor displacements of 500, 1,000 and 2,000 m from the source, respectively) as described in detail in Step 2.

The sound power level spectrum for the HH-3 helicopter is calculated in a similar manner, except that the reference measured *maximum* sound pressure level spectra are found in True et al. (1977, pp. 509-510) for level flight at a slant distance of 500 ft. These data are for two separate flybys; therefore, the greater of the two maximum levels measured in each 1/3 octave-band is used.

Step 2. Calculate Sound Pressure Levels at Receptor Locations

Based on the source and receptor locations presented in Tables B.5 and B.6, straight line propagation path lengths (slant distances) are computed. The sound pressure level spectrum at a specific location in the outdoor environment due to a specific sound power spectrum emitted by a source at some distance away is affected by atmospheric temperature, humidity, wind speed, wind direction, and turbulence. All of these variables are functions of height above the ground. Ground conditions can be important as well; e.g., vegetation, hills, structures, etc. Regarding topography, however, the terrain in the vicinity of the Massachusetts Military Reservation is relatively flat. Considering that the treatment of the effects of extreme meteorology on noise propagation requires models that are currently at the research level and use data that are not available at the site, standard-day conditions are assumed for the purposes of this comparison of F-106, F-16, and F-15 impacts. In any case, whatever systematic differences (between F-106 and F-16 or F-15 results) might exist under standard-day conditions, they would remain true under extreme meteorological conditions.

The general engineering expression for sound pressure level L_p (in dB referenced to 20 μPa), at a distance r (in meters) and angle θ from an isotopic sound source emitting sound power at a level L_w (in dB referenced to 1 pW) in free space is (Beranek, 1971):*

$$L_p = L_w + Q_\theta - 20 \log r - A_e - 10 \log 4\pi \quad \text{(B.1)}$$

A_e is defined as excess attenuation due to air absorption, meteorological effects and barrier effects (walls, topography, etc.) in decibels. For a source in free space (aircraft flying), $Q_\theta = 0$. For a source on or close to the ground, the approximation $Q_\theta = 3$ is made as a conservative assumption of a perfectly reflecting ground plane (which is essentially true for low-frequency sound). A_e, a function of frequency, is calculated from Air Force data previously referenced (Speakman et al., 1978b) for air-to-ground propagation (flying aircraft sources). For ARNG weapons and demolition noise sources on the ground, A_e is calculated from the data given in Table 4.2 of Bolt Beranek and Newman, Inc. (1984) (A_e = DT - 20 log r + 8, where DT is the distance-term value as given in the referenced table). The practical value of using these references for the calculation of A_e values as a function of frequency is that they represent empirical experience and include the effects of typical microturbulence in the atmosphere and ordinary outdoor groundcover under level-terrain conditions.

Step 3. Compute Loudness due to Each Source Contribution

The fundamental problem of comparing the relative subjective magnitude (i.e., as perceived by human hearing) of both steady sounds (aircraft) and impulsive sounds (weapons) is addressed in this study by the use of the loudness scale of measure in sone units. The nationally standardized method for calculating the loudness of noise in sone units is currently documented in detail by the American National Standards Institute (1980) and is based on the Mark VI method of S.S. Stevens, first published in 1961. After extensive additional research, Stevens published an improved Mark VII method (Stevens, 1972). Although the Mark VII procedure has not yet replaced Mark VI as the national standard, it is used in this study as a superior alternative (Scharf et al., 1977, 1979). The most recent international comparative studies of all descriptors in common use (including A-weighted decibel scales) have demonstrated the superiority of the Stevens Mark VII loudness model for characterizing subjective magnitude (as distinguished from annoyance or community complaints) of both steady and impulsive sounds (Van Wyck, 1981; Schultz, 1982a; Kryter, 1984).

A special advantage in using the loudness scale in sones for this study is the linear subjective nature of the scale; i.e., the perceived magnitude is directly proportional to the sone value. Thus, a sound of 100 sones sounds twice as loud as a

*If the sound source has directionality, an additional correction term, the source directivity index (D.I.) for the angle θ must be added to the right side of the equation. Also, a correction term for deviation of the acoustic impedance of air from 40 mks rayls (its value at 20°C and 1000 millibars atmospheric pressure) is not included in the right side of the equation because it is assumed to be negligible.

sound of 50 sones. However, the rule for summation is not as simple: eight identical sources are only twice as loud, i.e., the sone value is doubled for every 9-dB change in level, provided the frequency content does not change. (By comparison, a second identical source adds 3 dB to the noise *level* of one of the sources, and 10 identical sources add 10 dB to the noise *level*). The above property of the sone scale provides a means of displaying noise magnitudes of various sources as vertical bars, the heights of which are proportional to their subjective strengths. As a result, the final computations made in this step convert the sound pressure level spectra predicted at each receptor location to sone values, which are plotted in Figs. B.8 through B.18.

One sound is said to mask another when the masked sound cannot be distinguished (is inaudible) in the presence of the louder sound. Except when sound levels are as low as the threshold of hearing, masking is a complex function of the relative frequency content of the two sounds. For example, a sound having only high-frequency content cannot mask a sound having only low-frequency content. However, a high-amplitude, low-frequency sound can mask a high-frequency sound. A special analysis of audibility (detectability) must be made with 1/3-octave-band sound pressure level spectra to determine whether masking occurs in a specific situation (Fidell and Horonjeff, 1982). If two sounds are identical, or at least have similar spectrum shapes, one will mask the other when the ratio of their loudnesses in greater than about 1.6:1, which corresponds to about 6 dB. However, when the frequency spectra are not similar, the required ratio for masking can be much greater. For example, the very low-frequency character of demolition noise compared with the more-uniform wide bandwidth (greater high-frequency content) of aircraft jet noise results in a ratio of about 22:1 or more (approximately 40 dB or more, A-weighted) to cause total masking at the moment of firing.

B.3.3 Discussion of Results

The subjective magnitudes (loudness in sones) at the 11 receptor locations for the various noise sources from the four ARNG/ANG/Coast Guard scenarios are illustrated with vertical bars in Figs. B-8 through B-18. In those figures, maximum loudness values are presented for each of the noise sources, since the sound levels are time dependent.

Scenario I (Demolition)

At all locations except in Sandwich near Snake Pond (receptor location 4), the loudness of demolition ranges from 2-50% of the lesser of the maximum loudness values of any F-106 or F-16 worst-case runway departure operations analyzed. Similarly, demolition loudness ranges from 16-130% of the lowest maximum loudness values of those F-15 approach and departure worst-case runway operations analyzed at each location.

In the case of Sandwich near Snake Pond (receptor location 4), the loudness of demolition ranges from 40-90% of the lowest maximum loudness values of F-106 or F-16 Runway 05 departures. However, in the case of F-15 approach and departure vs. F-106 departure comparisons at this location, the demolition loudness ranges from 150-240% of

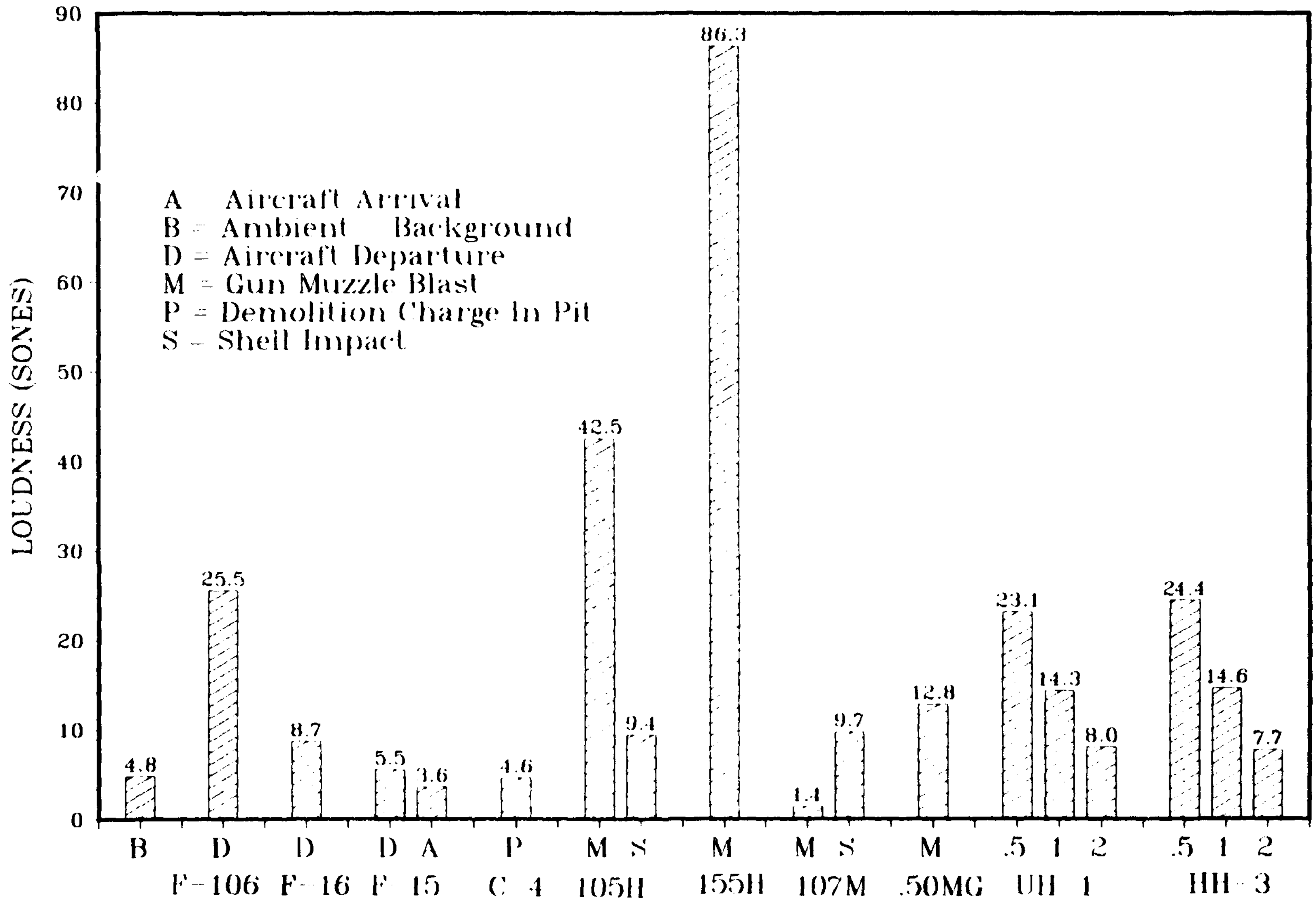

FIGURE B.8 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 1: Bourne (Route 6W residences near gun firing ranges and Jefferson Road) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

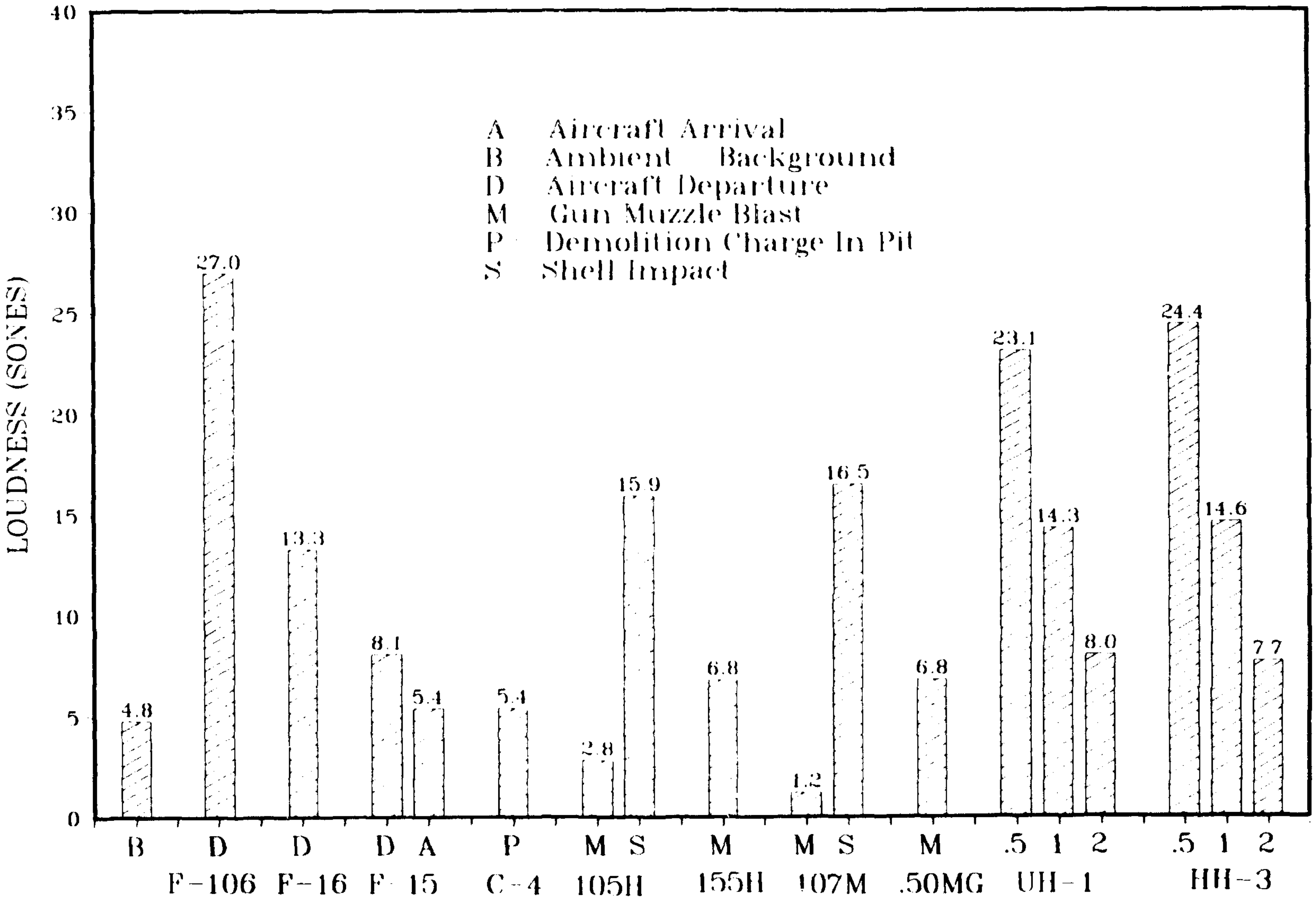

FIGURE B.9 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 2: Sandwich (Shawme-Crowell State Forest location nearest to shell-impact area) (Note: Value for B—ambient background--is estimated; helicopter distances are in km)

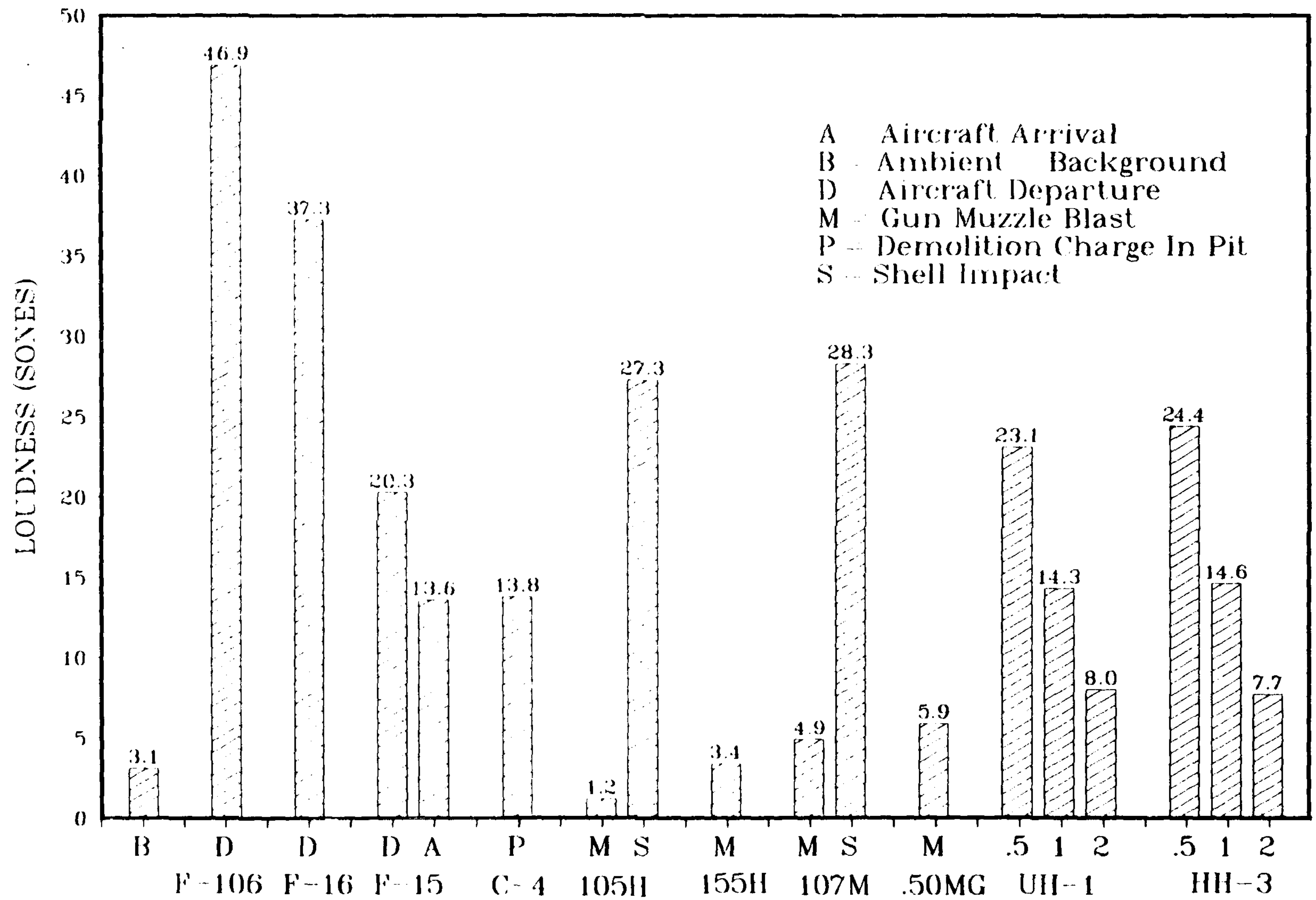

FIGURE B.10 Comparison of Predictions of Maximum Loudness Due to Artillery, Helicopter, and Jet Operations — Receptor 3: Sandwich (Forestdale residences on Greenway Road nearest shell-impact area) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

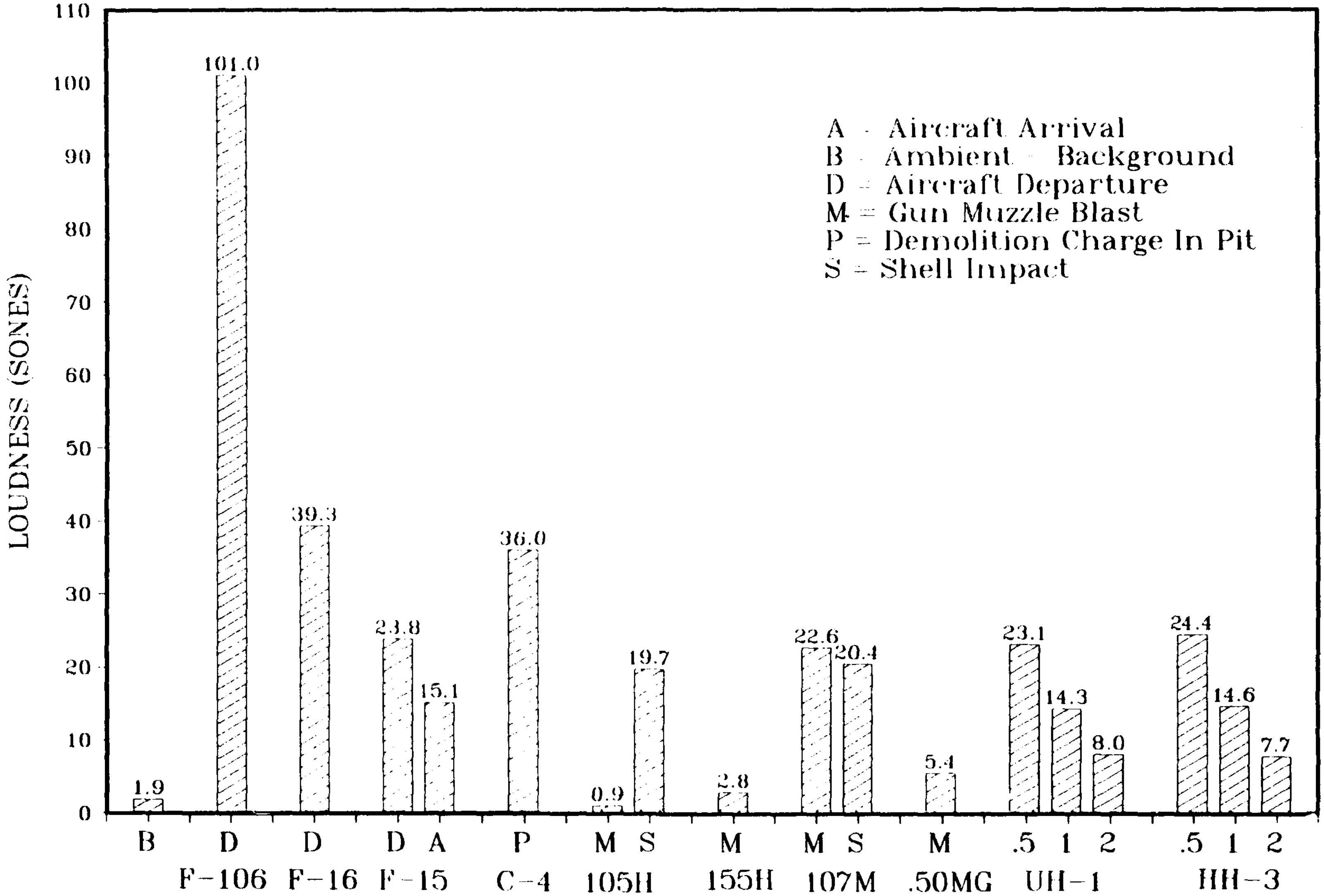

FIGURE B.11 Comparison of Predictions of Maximum Loudness Due to Artillery, Helicopter, and Jet Operations — Receptor 4: Sandwich (residences near Snake Pond closest to Demolition Range E-2 and mortar firing operation) (Note: Value for B--ambient background--is estimated; helicopter distances are in km)

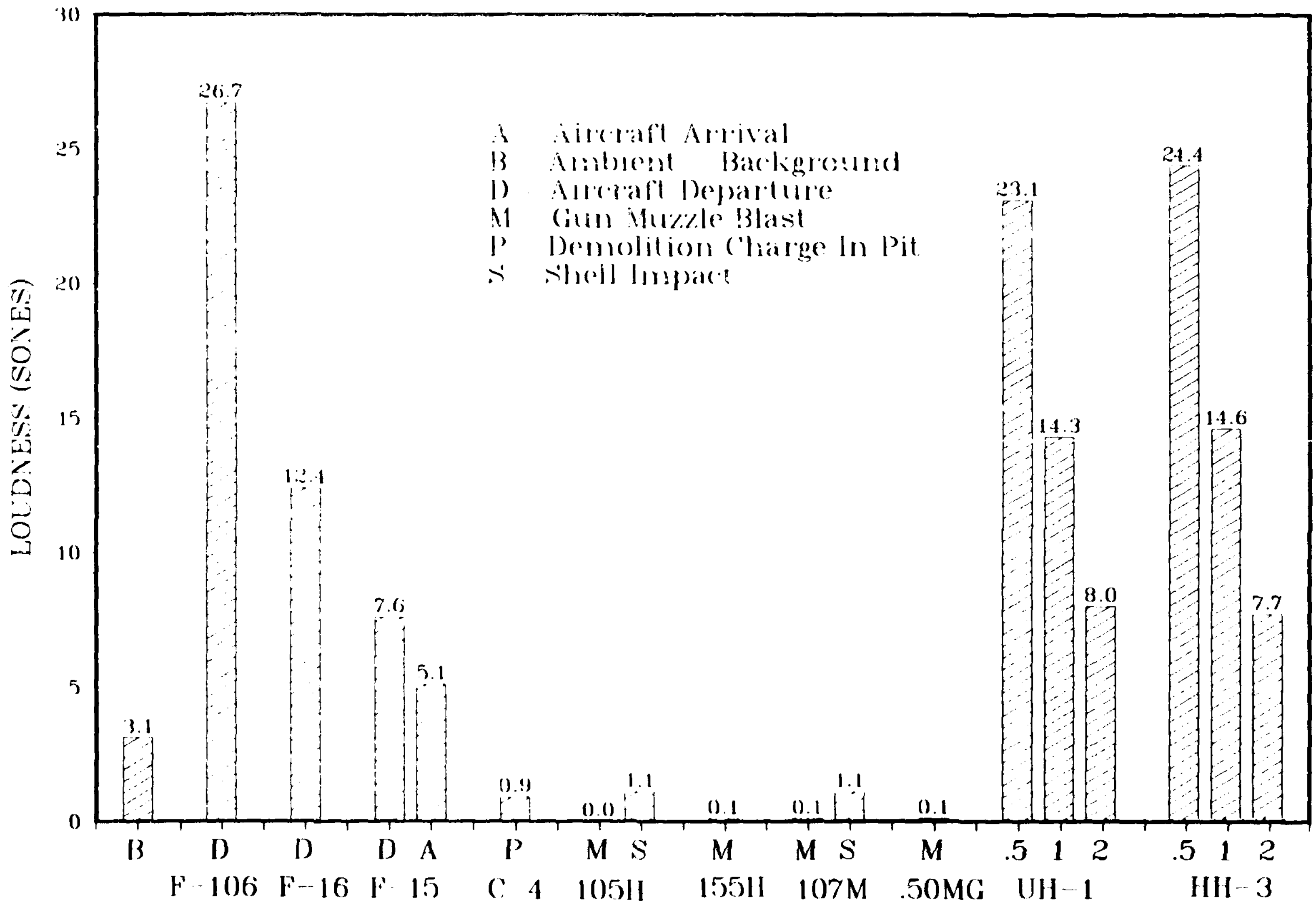

FIGURE B.12 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 5: Barnstable (Marstons Mills at intersection of routes 28 and 149) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

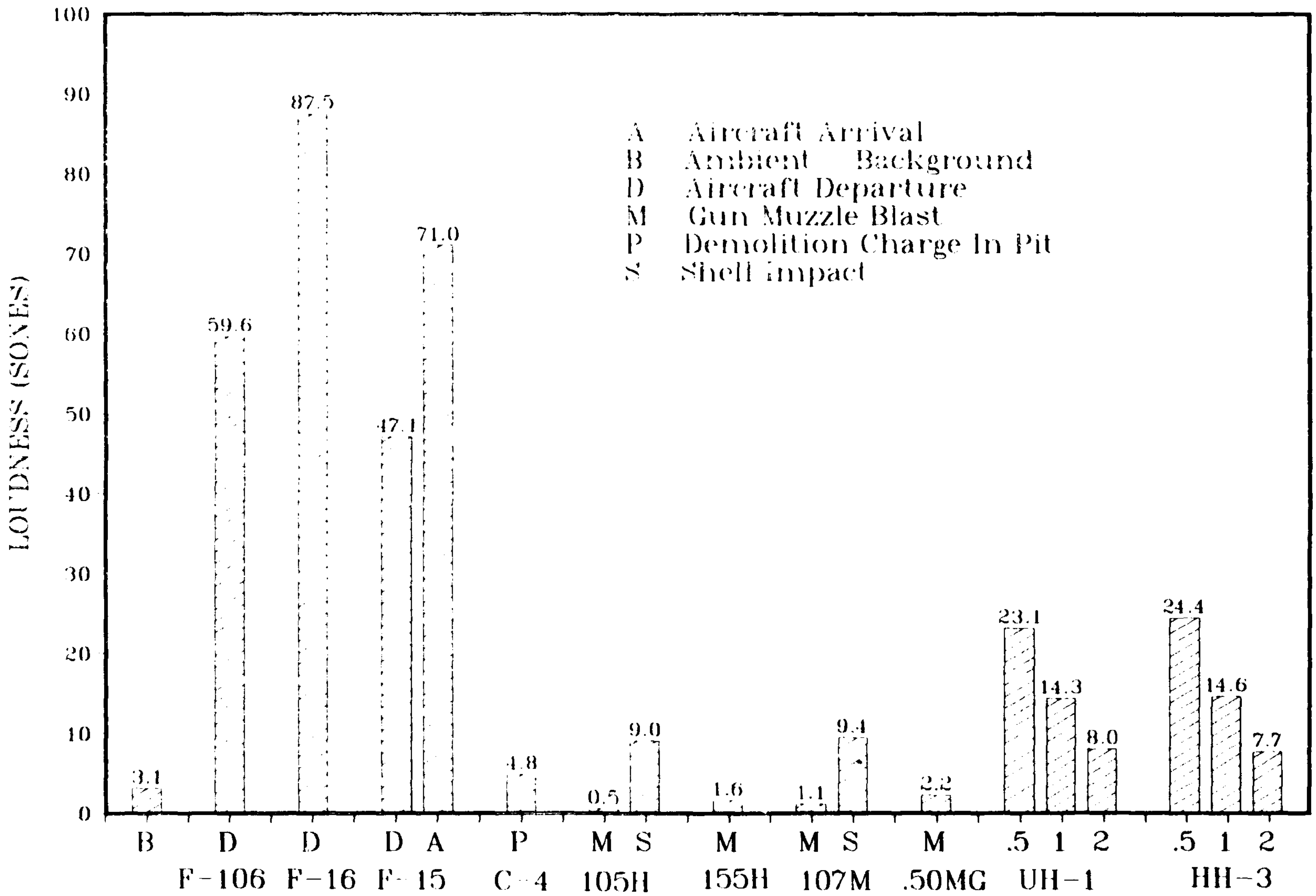

FIGURE B.13 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 6: Sandwich (residences on runway 05 centerline near Spectacle Pond) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

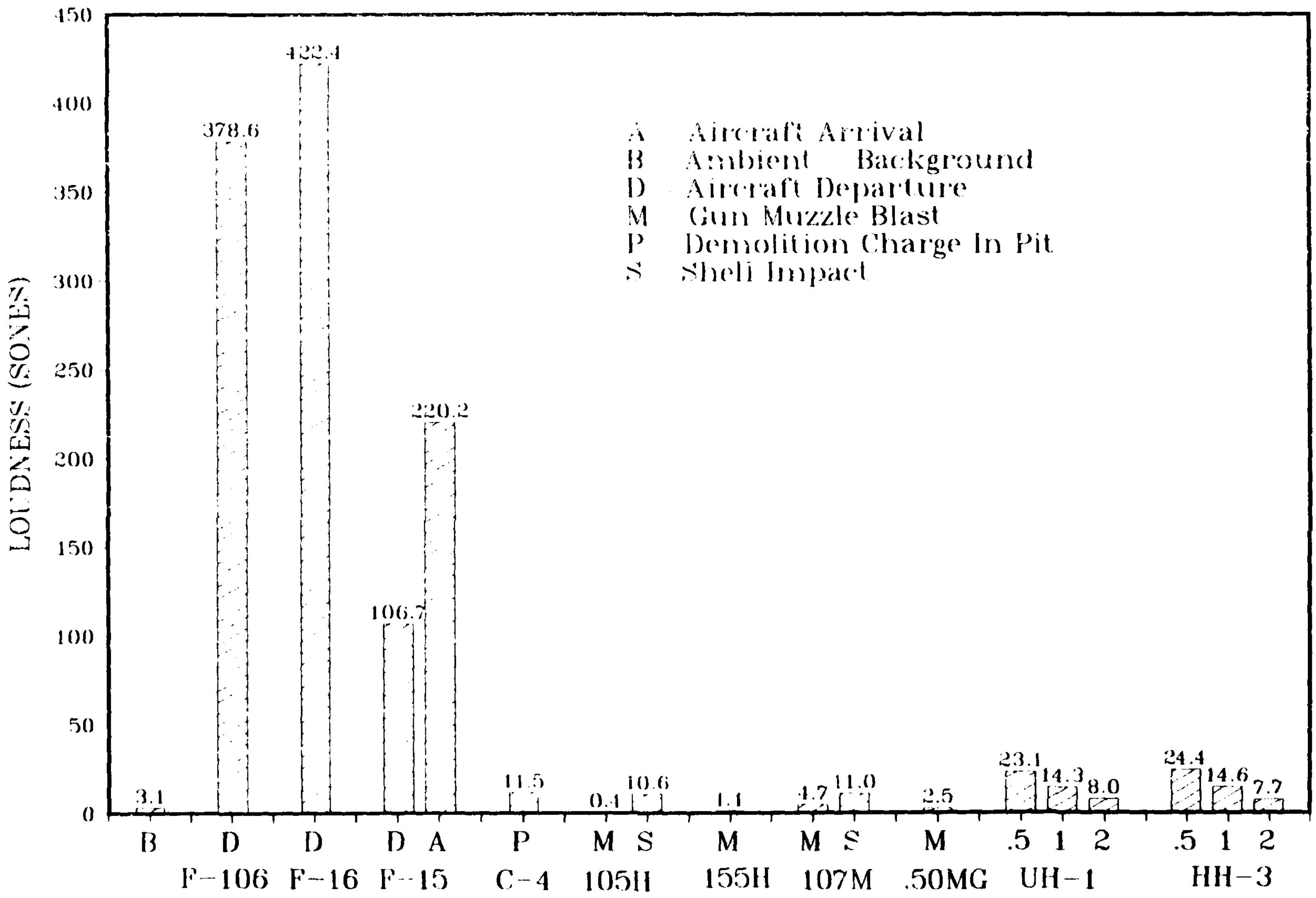

FIGURE B.14 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 7: Sandwich (residences on runway 05 centerline near Pimlico Pond) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

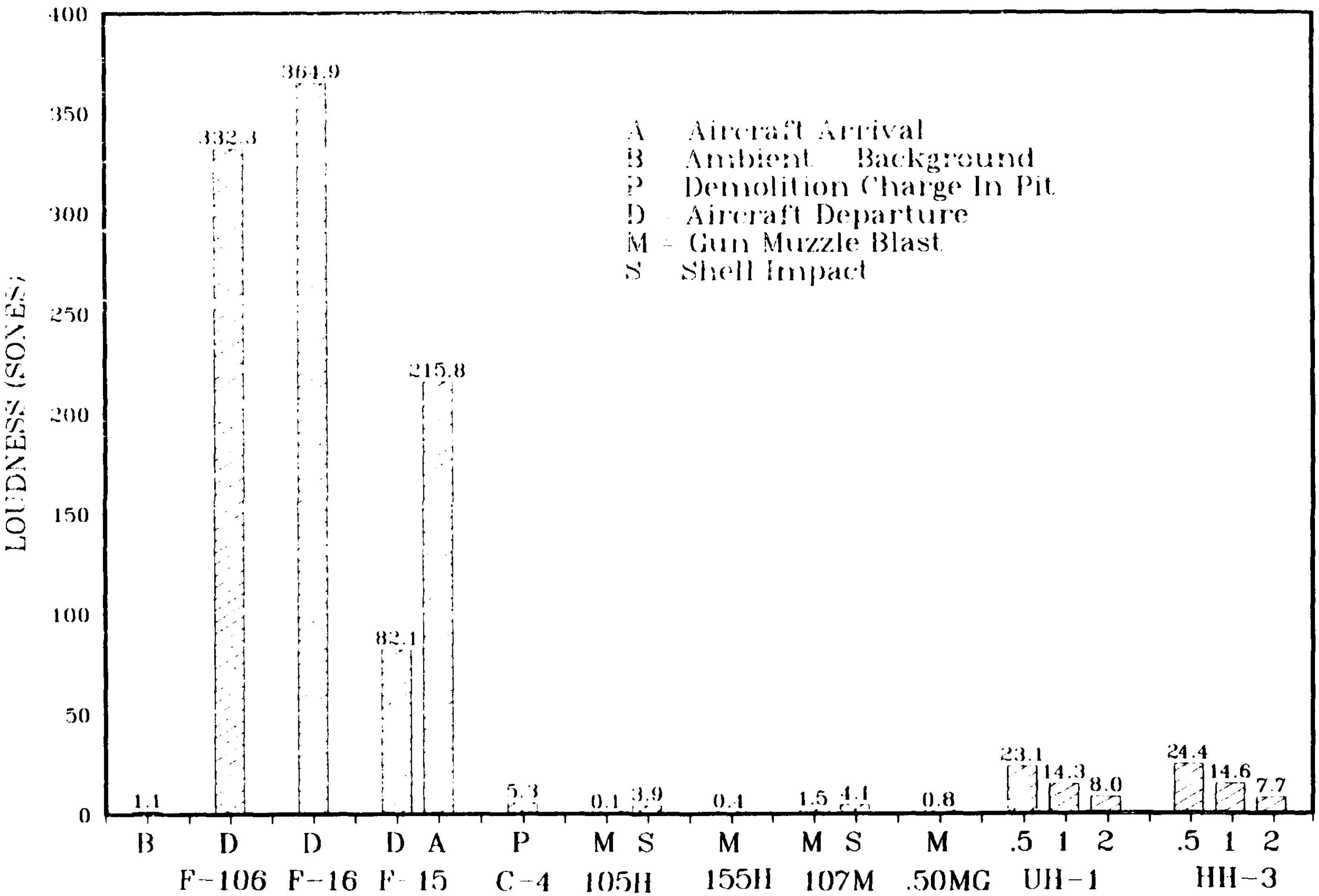

FIGURE B.15 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 8: Mashpee (residences under construction on runway 14 centerline between Moody and Washburn Ponds) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

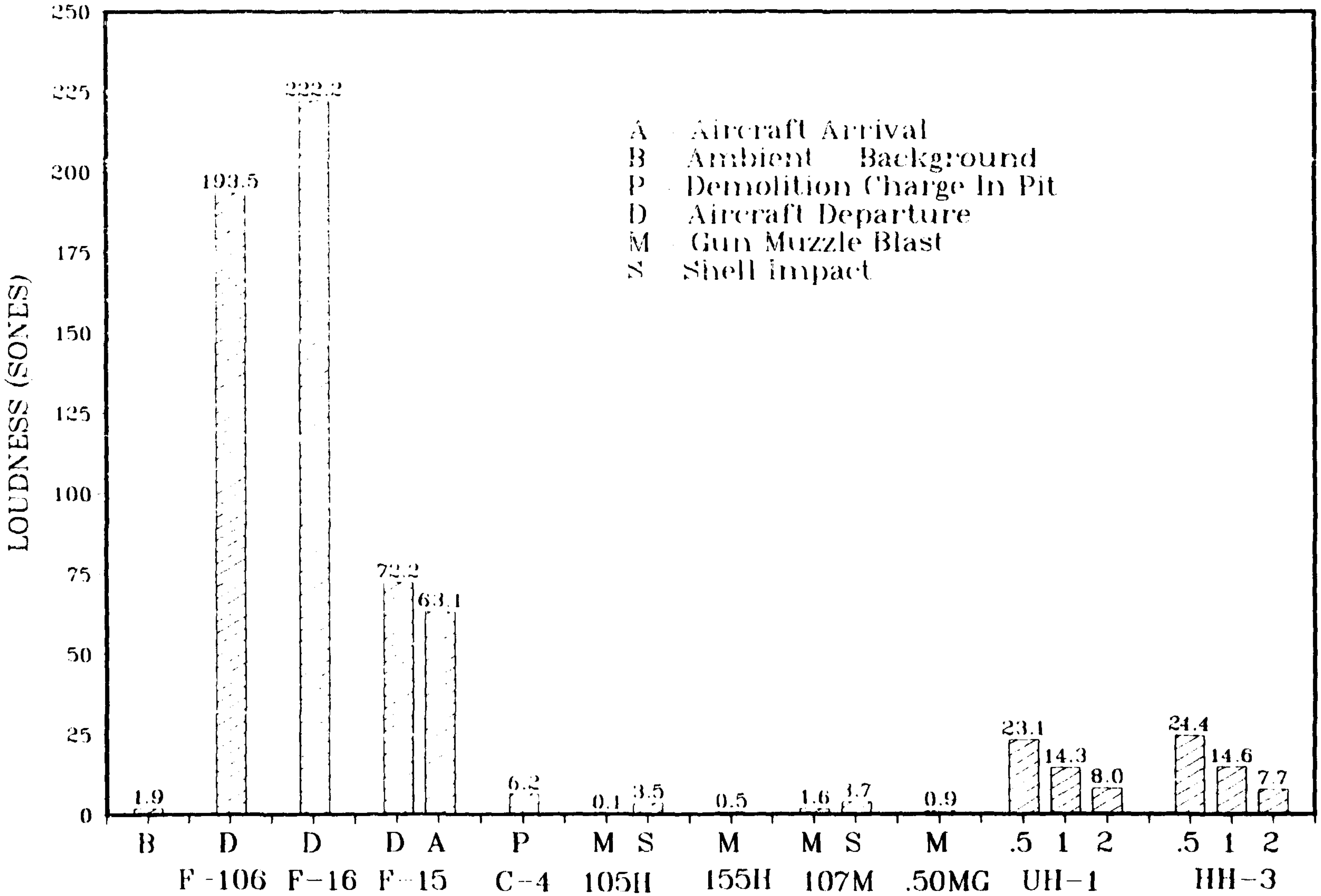

FIGURE B.16 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 9: Mashpee (residences near runway 23 centerline, near Ashumet Pond) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

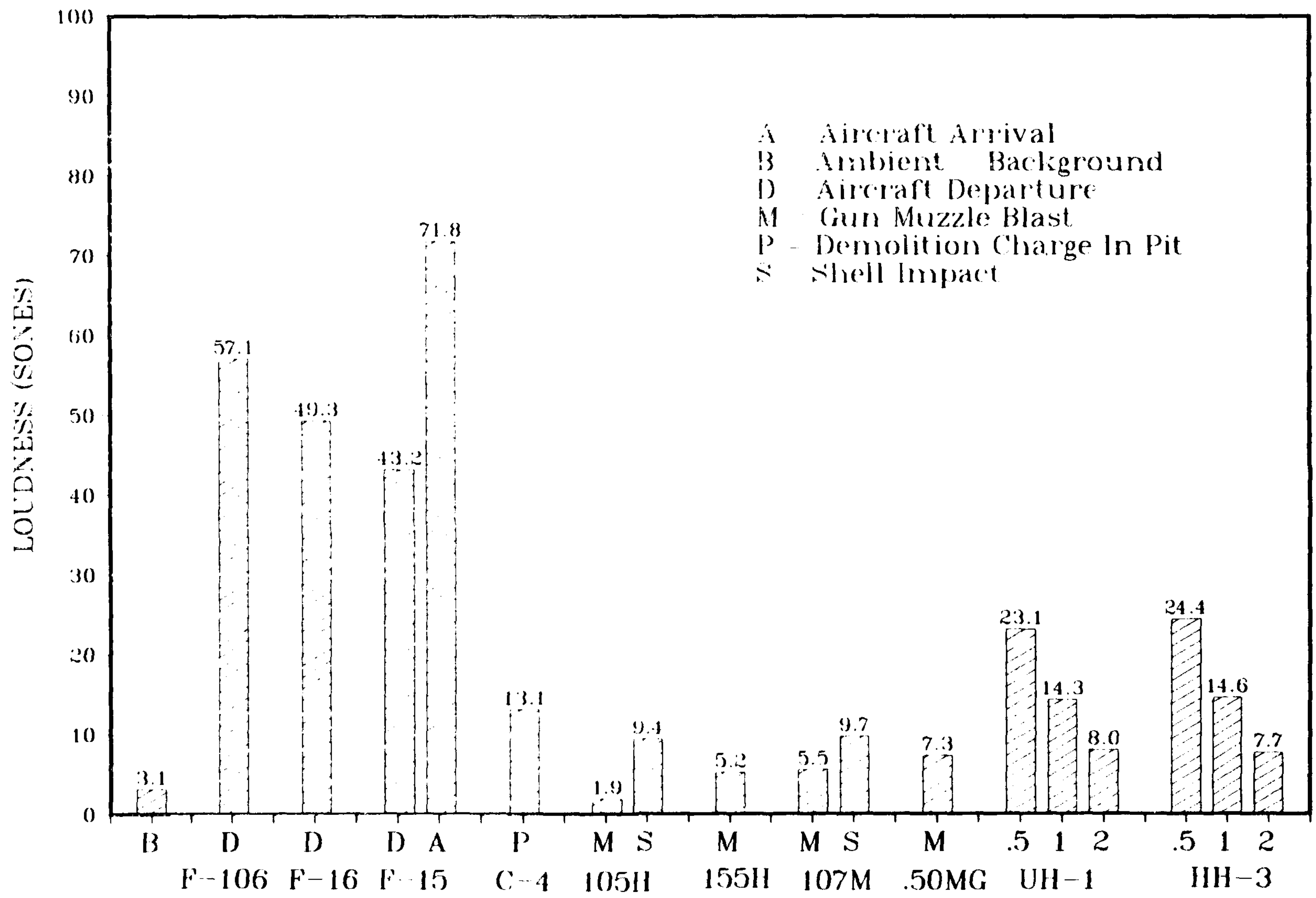

FIGURE B.17 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 10: Bourne (Pocasset residences on runway 32 centerline near Upper Pond) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

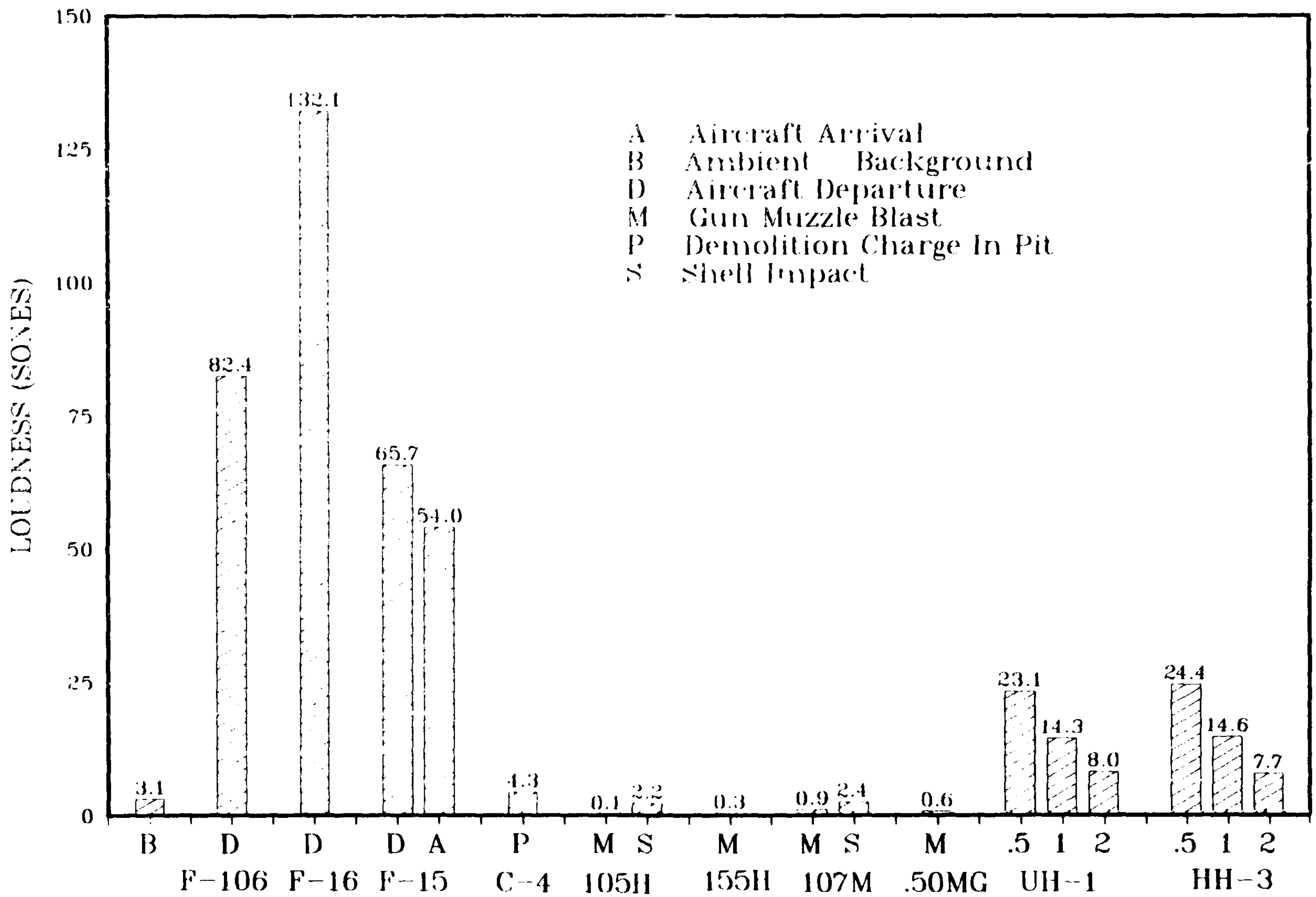

FIGURE B.18 Comparison of Predictions of Maximum Loudness due to Artillery, Helicopter, and Jet Operations — Receptor 11: Falmouth (Hatchville residences near runway 23 centerline) (Note: Value for B—ambient background—is estimated; helicopter distances are in km)

the F-15 maximum loudness; i.e., at the moment it occurs, demolition partially masks F-15 worst-case runway approach and departure, and is approximately 40% of the maximum loudness of F-106 Runway 05 departures.

Scenario II (Mortar Fire)

At all locations, except in Bourne at residences along Route 6W nearest the gun-firing ranges (receptor location 1) and in Sandwich at Shawme-Crowell State Forest nearest the shell-impact area (receptor location 2), the loudness of mortar fire (both muzzle blast and shell explosion) is less than either F-106 or F-16 maximum departure noise (whichever is lower at each location). In fact, it is totally masked by these aircraft departures on worst-case runways at locations in Sandwich near Pimlico Pond (receptor location 7) and at all three selected locations in Mashpee and Falmouth (receptor locations 8, 9, and 11). At receptor locations 1 and 2 (Bourne on Route 6W and Sandwich in Shawme-Crowell State Forest) the loudness of mortar fire (either muzzle blast or shell explosion) is less than the maximum loudness of F-106 departures but greater than the maximum loudness of F-16 departures (on worst-case runways).

The situation regarding F-106 vs. F-15 operations, compared with mortar fire, is essentially the same, except that in Sandwich at residences near Greenway Road (receptor location 3), the loudness of mortar shell explosions exceeds the maximum loudness of both approach and departure of F-15 aircraft on worst-case runways (as it also does at both receptor locations 1 and 2). At all other locations (4 through 11) it ranges from 4-150% of the maximum loudness of F-106 or F-15 departures or F-15 approaches on worst-case runways, whichever is lowest at each location. In Falmouth at Hatchville residences (receptor location 11) it is totally masked by F-106 and F-15 departures on Runway 23, as well as by F-15 approaches on Runway 05.

Scenario III (Machine-Gun Fire)

At all locations except in Bourne at residences along Route 6W nearest the gun-firing ranges (receptor location 1), the loudness of machine-gun-fire bursts is less than the maximum loudness of either F-106 or F-16 departures on worst-case runways, whichever is lower at each location. It ranges from 0.2-50% of the lesser maximum loudness of either of these aircraft operations on worst-case runways at each location. It is totally masked by F-106 or F-16 worst-case runway departures at all selected locations in Barnstable, Mashpee, and Falmouth, as well as in Sandwich near Spectacle and Pimlico Ponds (receptor locations 5-9 and 11) by F-106 or F-16 departures on Runway 05.

With regard to F-106 vs. F-15 operations, compared with machine-gun fire, the situation is essentially the same, except that in Sandwich at Shawme-Crowell State Forest nearest the shell-impact area (receptor location 2), the loudness of machine-gun-fire bursts is greater than the maximum F-15 approach noise on Runway 23, as it also is in Bourne at residences along Route 6W nearest the gun-firing ranges (receptor location 1) when F-15 approach is via Runway 14. At all other locations (receptor locations 3-11) the loudness of machine-gun fire ranges from 1-40% of the maximum loudness of F-106 or F-15 departures or F-15 approaches on worst-case runways,

whichever is lowest at each location. It is totally masked by F-106 or F-15 worst-case runway departures or F-15 approaches at all selected locations in Barnstable, Mashpee, and Falmouth, as well as in Sandwich near Spectacle and Pimlico Ponds (receptor locations 5-9 and 11) by F-106 or F-15 departures on Runway 05 or by F-15 approaches on Runway 23.

Scenario IV (Howitzer Gun Fire)

At all locations except the northernmost two in Bourne and Sandwich (receptor locations 1 and 2), this scenario yields results similar to Scenario II (Mortar Fire) because the 105-mm HE howitzer shell and 107-mm mortar shell are very close in charge weight (81 oz and 92 oz respectively), explode at the same location (impact area), and are predominant in loudness over muzzle blast noise for both mortars and howitzers at all receptor locations except 1 and 4. Specifically, at receptor locations 3-11, the loudness of howitzer firing (including 105-mm and 155-mm muzzle blasts and 105-mm HE shell explosions) is less than either F-106 or F-16 worst-case runway maximum departure noise (whichever is lower); it ranges from 1-70% of the maximum worst-case runway loudness of those aircraft operations at those locations. The howitzer firing noise is totally masked by these aircraft operations at all three selected locations in Mashpee and Falmouth (receptor locations 8, 9, and 11), i.e., departures via Runways 14 and 23, as well as in Sandwich near Pimlico Pond (receptor location 7) by departures via Runway 05. At Bourne near the gun-firing ranges (receptor location 1), the loudness of howitzer firing ranges from 2-10 times the F-106 or F-16 maximum loudness produced by departures via Runway 32. In Sandwich at Shawme-Crowell State Forest nearest the shell impact area (receptor location 2), the loudness of 105-mm HE shell explosion ranges from 60% of F-106 departure maximum loudness (via Runway 05) to 120% of F-16 maximum departure loudness (via Runway 05).

For F-106 vs. F-15 operations, compared with howitzer fire, the situation is similar to that of the F-106 vs. F-16 for receptor locations 1, 2, and 5-11, in terms of the qualitative relative magnitude of ordnance loudness relative to worst-case aircraft flight operations. The loudness of howitzer 155-mm HE shell impact explosions ranges from 4-20% of the maximum loudness of F-15 worst-case runway approaches and departures (whichever is least at each location). Total masking of the 105-mm HE shell bursts occurs in Falmouth at Hatchville (receptor location 11) for F-15 approaches via Runway 05 and departure via Runway 23. At Bourne near the gun-firing ranges (receptor location 1), the loudness of howitzer firing ranges from 2-24 times the F-106 or F-15 maximum loudness produced by departures via Runway 32 or F-15 approaches via Runway 14. In the three selected Sandwich locations nearest Camp Edwards (receptor locations 2-4), the loudness of the 105-mm HE shell explosions ranges from 20-290% of F-106 or F-15 departure maximum loudness (via Runway 05) or F-15 approach maximum loudness (via Runway 23).

B.3.4 General Summary of Analyses

General summaries of the results of these analyses are as follows:

- Single-event, worst-case ordnance noise only predominates at one of the selected locations: in Bourne near the gun-firing ranges (receptor location 1).

- Single-event, worst-case ordnance and fixed-wing aircraft noise is comparable at three of the selected locations, all in Sandwich: Shawme-Crowell State Forest northeast of Camp Edwards (receptor location 2), Forestdale near Greenway Road (receptor location 3), and west of Snake Pond (receptor location 4).

- Single-event, worst-case aircraft noise predominates at the remaining seven selected locations in Sandwich, Mashpee, Falmouth, and Bourne, which are all on or near runway centerlines (receptor locations 5-11).

- The maximum loudness of single-event, worst-case-location F-106 vs. F-16 departures at Otis ANGB is typified by a 50% reduction in loudness for the F-16 at takeoff power relative to the F-106 using afterburner, and a 15% increase in loudness for the F-16 at takeoff power relative to the F-106 at takeoff power.

- The maximum loudness of single-event, worst-case F-106 vs. F-15 departures at Otis ANGB is typified by a 75% reduction in loudness for the F-15 at takeoff power relative to the F-106 using afterburner, and a 50% reduction in loudness for the F-15 at takeoff power relative to the F-106 at takeoff power.

- The maximum loudness of a single-event F-15 approach relative to an F-15 departure at Otis ANGB is typified by a range from 1/3 lower loudness at locations far offset from the approach centerline, to as much as 2 1/2 times greater loudness at locations on the approach centerline within 4,000 ft of the runway (approach end).

- The loudness of UH-1 and HH-3 helicopters in level flight is comparable.

- UH-1 and HH-3 helicopter noise is unlikely to be predominant, relative to fixed-wing aircraft noise, at any of the selected single-event analysis receptor locations near Camp Edwards and in Barnstable (receptor locations 1-5).

- Worst-case UH-1 and HH-3 helicopter noise is insignificant relative to worst-case fixed-wing aircraft noise at all selected single-event analysis locations on runway centerlines or in Mashpee and Falmouth (receptor locations 6-11).

Another way of interpreting the data illustrated in Figs. B.8 through B.18 is to compare the changes in relative loudness magnitudes of existing F-106 (plus ordnance) activity with the sums of alternative F-16 (plus ordnance) or F-15 (plus ordnance) activity loudness magnitudes. A 40% reduction in loudness corresponds to a 6-dB or more reduction of A-weighted level, which, in turn, is definitely noticeable to a majority of community residents (Schultz, 1982b). Accordingly, if the criterion is adopted that a decrease of loudness (sone) value by 40% or more constitutes a *significant* reduction, a table can be constructed listing, for each receptor location, the significance of each conversion alternative in terms of single-event maximum noise impacts, as is summarized in Table B.8.

Clearly, the relative effects of the various noise sources at any receptor location are dependent upon the relative distances from those sources. For locations close to the jet operations, the jet noise predominates. For locations close to ARNG gun fire (muzzle or shell explosion noise), the impulsive noise predominates over the distant jets at the moment the demolition or gunfire activities occur. It should be kept in mind, however, that these comparisons of loudness were made assuming that the maximum noise of each source occurred at the same time for each receptor. In reality, for helicopter and jet noise, there is an increase, then a decrease in loudness (centered about the maximum), corresponding to passage of the aircraft.

TABLE B.8 Prediction of Change in Maximum Noise Impacts (in terms of loudness) due to Aircraft Conversion

	Scenario[a]							
	Demolition		Mortar		Machine Gun		Howitzer	
Receptor Location	F-106 to F-16	F-106 to F-15	F-106 to F-16	F-106 to F-16	F-106 to F-16	F-106 to F-15	F-106 to F-16	F-106 to F-15
1	SR	SR	SR	SR	SR	SR	IR	IR
2	SR	SR	IR	SR	SR	SR	IR	SR
3	IR	SR	IR	SR	IR	SR	IR	SR
4	SR	SR	SR	SR	SR	SR	SR	SR
5	IR	SR	IR	SR	IR	SR	IR	SR
6	IR	IR	IR	IR	IR	IR	IR	IR
7	IR	SR	IR	SR	IR	SR	IR	SR
8	IR	SR	IR	SR	IR	SR	IR	SR
9	IR	SR	IR	SR	IR	SR	IR	SR
10	IR	IR	IR	IR	IR	IR	IR	IR
11	IR	IR	IR	IR	IR	IR	IR	IR

[a]SR = significant reduction (40% or more reduction in loudness [sone] value) (noticeable to human ear); IR = insignificant reduction (may not be noticed by human ear).

B.4 REFERENCES*

American National Standards Institute, *American National Standard Procedure for the Computation of Loudness of Noise*, ANSI Standard S3.4-1980, New York (Oct. 1980).

Beranek, L.L., *Noise and Vibration Control*, McGraw-Hill Book Co., New York (1971).

Bolt, Beranek and Newman, Inc., *Electric Power Plant Environmental Noise Guide*, Second Edition, Volume I, Edison Electric Institute, Washington, D.C. (1984).

Department of the Army, *Environmental Quality, Environmental Protection and Enhancement*, Army Regulation No. 200-1, Chapter 7, Washington, D.C. (June 15, 1982.)

Fidell, S., and R. Horonjeff, *Graphic Method for Predicting Audibility of Noise Sources*, Air Force Wright Aeronautical Laboratories Report AFWAL-TR-82-3086, Wright-Patterson Air Force Base, Ohio (Oct. 1982).

Frederick, R.A., SGM, Senior Operations Sergeant, Headquarters, Camp Edwards, Mass., personal communication (Aug. 19, 1986).

Kryter, K.D., *The Effects of Noise on Man*, Academic Press, Inc., New York (1970).

Kryter, K.D., *Loudness, Noisiness, and Vibration Effects*, Chapter 5 in *Physiological, Psychological, and Social Effects of Noise*, National Aeronautics and Space Administration Report No. RP-1115, Langley Research Center, Hampton, Va. (July 1984).

Kryter, K.D., and G.R. Garinther, *Auditory Effects of Acoustic Impulses from Firearms*, Supplement 211, Acta Oto-Laryngologica, Uppsala, Sweden (1965).

Lewis, N., U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, Md., personal communication (Aug. 24, 1986).

Little, L.N., V.I. Pawloska, and D.L. Effland, *Blast Noise Prediction*, Volume II: *BNOISE 3.2 Computer Program Description and Program Listing*, U.S. Army Construction Engineering Research Laboratory Report CERL-TR-N-98, Champaign, Ill. (March 1981).

Luz, G.A., *Data Base for Assessing the Annoyance of the Noise of Small Arms*, U.S. Army Environmental Hygiene Agency Report HSHB-OB/WP, Technical Guide No. 135, Aberdeen Proving Ground, Md. (June 1983).

McBryan, J., *Predicting Noise Impact in the Vicinity of Small Arms Ranges*, U.S. Army Construction Engineering Research Laboratory Interim Report N-61, Champaign, Ill. (Oct. 1978).

*In this reference list, the term "personal communication" is used to indicate a telephone conversation, a face-to-face conversation, or a written communication.

Metcalf, H.L., *Memorandum for AFPREV, Use of C-weighted Noise Measure*, Department of Defense, Washington, D.C. (June 29, 1977).

Piercy, J.E., and T.F.W. Embleton, *Sound Propagation in the Open Air*, Chapter 3 in *Handbook of Noise Control*, Second Edition, C.M. Harris (editor), McGraw-Hill Book Co., New York (1979).

Raspet, R., M. Kief, and R. Daniels, *Prediction and Modeling of Helicopter Noise*, U.S. Army Construction Engineering Research Laboratory Technical Report N-186, Champaign, Ill. (Aug. 1984).

Scharf, B., R. Hellman, and J. Bauer, *Comparison of Various Methods for Predicting the Loudness and Acceptability of Noise*, Part I, U.S. Environmental Protection Agency Report No. 550/9-77-101, Washington, D.C. (Aug. 1977).

Scharf, B., R. Hellman, and J. Bauer, *Comparison of Various Methods for Predicting the Loudness and Acceptability of Noise*, Part II, U.S. Environmental Protection Agency Report No. 550/9-79-102, Washington, D.C. (Aug. 1979).

Schomer, P.D., R.J. Goff, and L.M. Little, *The Statistics of Amplitude and Spectrum of Blasts Propagated in the Atmosphere*, Volumes I and II, U.S. Army Construction Engineering Research Laboratory Technical Reports (TR) N-13/ADA033361 and ADA033646, Champaign, Ill. (Nov. 1976).

Schomer, P.D., P.J. Goff, and L.M. Little, *Blast Noise Predictions, Volume I: Data Bases and Computational Procedures*, U.S. Army Construction Engineering Research Laboratory Technical Report N-98, Champaign, Ill. (March 1981).

Schultz, T.J., *International Round Robin to Evaluate Loudness Calculation Methods*, Section 3.E.(e) in *Community Noise Rating*, Second Edition, Applied Science Publishers, Ltd., New York (1982a).

Schultz, T.J., *Composite Noise Rating for Community Noise*, Section 2.H.1 in *Community Noise Rating*, Applied Science Publishers, Ltd., New York (1982b).

Snow, W.B., *Survey of Acoustic Characteristics of Bullet Shock Waves*, IEEE Transactions on Audio and Electroacoustics, Volume AU-15, No. 4 (Dec. 1967).

Speakman, J.D., R.G. Powell, and R.A. Lee, *Community Noise Exposure Resulting from Aircraft Operations*; Volume 3: *Acoustic Data on Military Aircraft: Air Force Attack/Fighter Aircraft*, U.S. Air Force Aerospace Medical Research Laboratory Report AMRL-TR-73-110(3), Wright-Patterson Air Force Base, Ohio (Feb. 1978a).

Speakman, J.D., R.G. Powell, and R.A. Lee, *Community Noise Exposure Resulting from Aircraft Operations*; Volume 4: *Acoustic Data on Air Force Trainer/Fighter Aircraft*, U.S. Air Force Aerospace Medical Research Laboratory Report AMRL-TR-73-110(4), Wright-Patterson Air Force Base, Ohio (Feb. 1978b).

Stevens, S.S., *Procedure for Calculating Loudness: Mark VI*, J. of the Acoustical Society of America, 33(11):1577-1585 (Nov. 1961).

Stevens, S.S., *Perceived Level of Noise by Mark VII and Decibels (E)*, J. of the Acoustical Society of America, 51(2):575-593 (1972).

Stockhaus, J.A., LTC, Facility Management Officer, Massachusetts Army National Guard, Boston, personal communication (June 1986).

True, H.C., E.J. Rickley, and W. Letty, *Helicopter Noise Measurements Data Report*, Volume 2, U.S. Department of Transportation, Federal Aviation Administration Report FAA-RD-77-57, Vol. 2, Transportation Systems Center, Cambridge, Mass. (April 1977).

U.S. Air Force, *Noise Produced on the Ground by UH-1N Aircraft during Flight Operations*, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio (May 9, 1984).

U.S. Army, *Browning Machinegun Caliber .50 HB, M2*, Field Manual FM 23-65, Washington, D.C. (May 1972).

U.S. Army, *Ammunition, General*, Technical Manual TM 9-1300-200, Washington, D.C. (Oct. 1969).

Van Wyck, A.J., *A Comparison of Measurement Methods for Assessing Human Perception of Loudness: An International Survey*, Acustica, 49:33-46 (Sept. 1981).